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Usage and Benefits of Modern Technological Tools for Postsecondary Students from Different Countries with a Focus on STEM

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This article reports on a recent survey conducted among a sample of 291 students from four international universities located in Germany, China, Brazil, and the USA. The study investigated the effects and benefits of new technologies, tools, and learning methods in higher education. The empirical analysis explored the similarities and differences between the various countries concerning the students' acceptance, performance, and attitude within the technological learning environment. The survey was carried out via the online tool "Questback". The participants showed several similarities and were very familiar with new technologies for learning, but the usage intensity at the four universities differed. Moreover, special tools and methods were preferred by some groups. The article sums up the key results of the cross-cultural analysis, highlighting the results for STEM subjects and educational implications.

Keywords: technology use in higher education, higher education pedagogy in STEM, postsecondary international learners, learning with technological tools, cross-cultural analysis

In our modern world, technology rapidly changes the workplace and the demanded skillsets for employees within a short period. Meanwhile, education systems are slow in adapting to the new circumstances and making changes to traditional education programs to address students' needs in a technological society. As the demand for new skill sets increases, the challenge will be to anticipate what those skills might be. For some experts, the answer is STEM (Science, Technology, Engineering, and Mathematics) skills as well as coding so that people can develop or work with new technologies (May Lee et al., 2017; Patrinos, 2017). Thus, future workers need to adapt to the new challenges at the workplace. Nevertheless, cognitive skills, like problem-solving skills, thinking critically, learning skills to acquire new knowledge, communication, and personal skills (e.g., self-management) as well as social skills for collaboration, teamwork, and conflict resolution will be highly demanded in the future business world (Frezzo, 2017; Manvika et al., 2013). Therefore, higher education institutions must ensure that the effective use of technology for learning and teaching is built into curriculum design processes. This article provides insights related to such use of new technological tools (e.g., videos, podcasts, and learning apps) based on the views and experience of postsecondary students from different countries. The article is based on a comparative study that investigated similarities and differences of the usage and assessment of new technology and innovative tools by postsecondary students from four countries in learning STEM content. The focus is on comparison of the participants' level and type of usage of relevant tools in their learning, satisfaction with their own and instructors' technological competence, and prior educational information technology background.

Background and Related Literature

It is important for universities to make sure that the digital agenda is being led at top management levels and should embed digital capabilities into recruitment, staff development, appraisal, reward, and recognition. Academic leads for learning and teaching must also embrace technology-enhanced learning and the digital environment and recognize the relationship with other aspects of learning and teaching. But this change within the higher education sector is hard and slow (Hansen, 2018). Most of the time, singular approaches are conducted at universities to integrate STEM with new technology in existing, traditional curricula. For example, a best-practice approach is offered in statistical courses for business students at different German universities. But, for the students who take a course and pass the test successfully, after a while, the statistical knowledge is 'forgotten'. To avoid or reduce this effect, the use of new technological tools (e.g., videos, podcasts, or learning apps) that explain complex aspects of statistics, are applicable solutions to integrate STEM into the curriculum and keep the business students interested in STEM. This suggestion is reflected in another example of courses that interlinks STEM subjects with a student's majors is a new project at the DHBW Mannheim in Germany. In this project, students take virtual reality courses to gain a better understanding of complex mathematical or statistical concepts in a 3D perspective via a mobile virtual reality headset. The virtual reality technology helps the students to see mathematical or statistical concepts in a 3D room and to understand complex ideas more visually. Empirical study results show that virtual reality technology is an effective and joyful way of learning (Alexander et al., 2019).

Integrating and teaching STEM successfully across the globe is still highly demanding. An empirical study by the World Economic Forum (2018) showed that China, the USA, and Russia are the top countries with the most STEM graduates, whereas, for example, Germany do not have – in relation – as many successful STEM graduates per year (Baker, 2018). For instance, several years ago, higher education in China was a rare privilege enjoyed by a small, urban elite. But everything changed in 1999 when the government launched a program to massively expand university attendance. In that year alone, university admissions increased by nearly 50% and this average annual growth rate persisted for the next 15 years, creating the largest influx of university-educated workers into the labor market in history. The growth in the number of engineering students has been particularly explosive as part of the government's push to develop a technical workforce that can drive innovation. But overall student numbers have increased in all subjects – even in the humanities and social sciences. New universities have sprung up and student enrolment numbers have rocketed as the latest reports show (Stapleton, 2017). China as a best-practice case is a great role model for other universities from Germany or the USA. Nevertheless, it is necessary to expand the scope of STEM education, to ensure that students learn to evaluate and respond to the social, economic, and political consequences of their work. This does not mean adding existing humanities or social sciences courses to a STEM curriculum. It requires the development of an entirely new curriculum, giving the next generation of students the formal foundations – including shared vocabulary and intellectual frameworks – for considering the macro effects of their actions on society. However, many universities are adding ethics classes to the STEM curriculum. Others are enriching the existing STEM programs with social units, to enable STEM students to gain a deeper understanding of how technology affects humanity. With the corona-virus crisis and the resulting experiences in the long lockdowns phase with social distancing, these programs are considered important and appreciated by the students. Thus, expanding STEM education to include broader considerations will serve as a cornerstone of a more comprehensive long-term strategy to ensure that technology positively serves society (Baker, 2018).

The concerns and importance of integrating the use of current technologies to enhance teaching and learning in relation to STEM disciplines at university level require research to understand the situation from international students' perspectives. In particular, far too little attention has been paid in research to the following key questions:

- What are effective technological tools to teach STEM and other study-related topics to students effectively across the world?
- Are there any cultural differences towards the usage and acceptance of new tools and innovative methods among different countries, like Germany, China, Brazil, and the USA?

It is important to see the variations in using technology in higher education between various countries to identify new possibilities and develop customized teaching and learning approaches (Alexander et al., 2019; Schulte et al., 2014). Thus, this article aims to make a contribution to this area of research based on a study that explored the similarities and differences in the usage and acceptance of new technological tools as well as innovative methods at four different universities in Germany, China, Brazil, and the USA from their students' perspectives.

Theoretical Perspectives

In this study *new technology tools* or *new technologies* or *innovative technologies* refers to a broad range of current technological tools and digital media that can be used to transform postsecondary education in innovative or non-traditional ways to support students' learning in ways that are meaningful to the students. These technologies include videos, podcasts, learning apps, virtual reality, emails, text, social media, and video conferencing platforms. They offer opportunities to meet the current high expectations of students concerning their academic education and the student-centered learning environments universities must offer (Adams Becker et al., 2018; Honal et al., 2018).

Adapting new technologies and innovative methods in the teaching process helps to meet the challenges of the digital age. Today's students are extensively familiar with new technologies and use them with high frequency (May Lee et al., 2017; Pimmer et al., 2016; Schulte et al., 2014). By integrating digital media and innovative technologies effectively in the curriculum, the students' needs and expectations can be met and a more individual studying experience can be offered. This integration requires the role of the teacher to change accordingly. The right usage and appropriate dosage of new tools within the curriculum have to be identified. The technological pedagogical content knowledge (TPACK) framework is helpful for educators in making decisions regarding this use of technology. Thus, it has relevance to the study being reported in this article in relation to exploring usage of technology and technological competence of students and lecturers in STEM-based courses.

The TPACK framework emphasizes how the variables of teachers' understanding of technology, pedagogy, and content interact with one another to produce effective teaching. This model has a strong impact on theory, research, and practice in teacher education and higher education of professionals (Koehler & Mishra, 2009; Koehler et al., 2013). The TPACK model suggests that educators must have comprehensive content knowledge referring to their teaching subjects as well as pedagogical knowledge about the variety of instructional practices, strategies, and methods to promote student learning. Technological knowledge is the last element of the TPACK model and refers to the teacher's knowledge of traditional and new technologies that can be integrated effectively into their teaching approach. According to the TPACK framework, technological pedagogical content knowledge should be used by lecturers to develop appropriate and context-specific teaching strategies and to develop learning environments that will promote students' motivation and learning performance (Koehler & Mishra, 2009; Koehler et al., 2013). This specifically includes the frequent usage of the local learning management system (Araeipour, 2013; Kim et al., 2006). In many cases, the digital technology skills of lecturers are limited and not used as the TPACK framework suggests (Koehler & Mishra, 2009). Thus, a professional skill set of pedagogical, social, and technological competencies for lecturers and clear work guidelines for learning and teaching are needed (Adams Becker et al., 2018; Alexander et al., 2019).

The future business world will be highly knowledge-driven. Thus, educators must use education to enable people to develop themselves according to this constant change and give them the skills they need for the new jobs of the 21st century (Hansen, 2018). They need to encourage much closer collaboration between lecturers and students, for example, by integrating the right technology in the classroom or online classes (Alexander et al., 2019; Frezzo, 2017).

The above perspectives of technological pedagogical knowledge based on TPACK and the use this knowledge in the postsecondary classroom or online courses provided the basis in framing this study. In particular, they were central to designing the research survey questions and interpreting the findings regarding students' usage of technology in STEM-based courses.

Methods

A quantitative methodology was used for this empirical study (Creswell, 2014). This method was appropriate for the survey design of the study to address the research question: what are the key differences and similarities towards the usage of new technology and innovative tools among the different institutions and countries, the tools that were mainly used for learning especially when students learn STEM content, and the prior educational information technology background of the students?

Participants

The total sample size of 291 participants consisted of students in a bachelor or master degree program at four different international universities. A more expanded view on cultural differences was given through the participation of universities in Germany, China, Brazil, and the USA. The German sample of 75 participants consisted of 34 female and 41 male students, the Chinese sample of 160 participants consisted of 108 female and 52 male students, the Brazilian sample of 28 participants consisted of 18 female and 10 male students, and the USA sample of 28 participants consisted of 16 female and 12 male students. The average age of the German and Chinese students was 22 years. The American participants were on average 23 years old and the students from Brazil were about 27. The majority of the total sample (56.4 %) were master-degree students, the rest were enrolled in bachelor programs. The total sample comprised of a mixture of business and technical/STEM students. All students had to take technical or mathematics-oriented courses as part of their study programs. The sample was based on the respondents to the questionnaires.

Data Collection and Analysis

Data collection instrument for the survey was a questionnaire. Only closed answer formats were used for the survey with seven-point Likert scales. The items and ranking scales were chosen for the survey design to meet statistics quality criteria (Creswell, 2014). The questionnaire consisted of five categories of questions/items as follows:

1. *Home university*. Participants were asked to evaluate characteristics of the university at which they were presently studying. They had to rate seven different statements (see Table 1); for example, "stable and reliable study conditions" and "friendly and competent lecturers". For the rating, a seven-point Likert scale from one ("strongly disagree") to seven ("strongly agree") was applied.
2. *Usage of relevant technological tools*. Participants were asked to indicate how often they used different technologies for studying. They had to indicate their intensity of usage for ten different tools (see Table 2), for example, "Internet search engines" and "blogs", on a seven-point Likert scale from one ("Not at all or very low utilization intensity") to seven ("Very high utilization intensity").
3. *Learning management system and learning apps*. Participants were asked to evaluate the learning management system and learning apps in higher education. They had to rate them based on eight different factors (see Table 3), for example, whether innovative and whether facilitate learning/working. They indicated their assessment on a seven-point scale with labels like "very bad" and "very good" or "not very innovative" and "very innovative" depending on the factor.
4. *Communication with lecturers*. Participants were asked to indicate how often they applied the different technologies for communication with their lecturers in general. They had to rate eight different ways of communicating (see Table 4), for example, by email and by text messages. On a seven-point Likert scale from one ("very low") to seven ("very high"), they had to indicate how often they used the different communication channels.
5. *Technological competence*. Participants were asked to indicate their level of satisfaction with their own technological competence and their lecturers' technological competence as well as with the information technology support at the university. They had to rate four different statements (see Table 5), for example, "degree to which lecturers use

technologies to support the learning process." They indicated their satisfaction on a Likert scale from one ("very dissatisfied") to seven ("very satisfied").

6. *Prior experiences with new technologies.* Participants were asked to evaluate their experience with new technologies and the internet in their youth (approximate age: 13 to 18 years). The focus was on their use in the context of high school education. They had to rate six different statements (see Table 6), for example, "In school, I learned how to use digital media and new technologies." They indicated their rating on a seven-point Likert scale from one ("strongly disagree") to seven ("strongly agree").

The survey was conducted through the online tool *Questback*. The students took part in the survey from August to October 2019. The statistical analysis was conducted with the IBM-Software SPSS version 27.0. The results were derived by descriptive analysis (mean, standard deviation) and regression models. The focus in this article is on comparison of the means for each category of the survey to determine the similarity and differences of the usage and assessment of new technology and innovative tools by the postsecondary students from the four different countries as well as other related factors covered in the survey.

Results and Discussion

The results of the study are presented for the six survey categories that addressed the participants' views of their home institution, level and type of usage of relevant tools in their learning, level of satisfaction with their own and instructors' technological competence, and prior educational information technology background. Statistics for each item are presented in tables for each category to provide the scope of the participants' responses within each category and across each country. However, emphasis is placed on describing and discussing the comparison among the countries to address this aim of the study. The section is organized with headings based on the six survey categories.

Image of Home University

Table 1 shows the results of the students' evaluation of the image of their home university across the four different groups. In general, the students seemed to have a positive image of their university. The Chinese and Brazilian students assessed their university slightly better than the students from Germany and the USA. One possible explanation for this could be that students from China and Brazil appreciate studying at a well-known university as a "privilege" more than the two other student groups (Germany and USA) that have easier access to higher education due to their societal and educational systems. The social pressure on students in China and Brazil is higher than in Germany and the USA (Brown, 2013). Therefore, their higher identification with the university and the pride to study there is potentially one of the reasons why these students perceived their home university more positively (Honal et al., 2018).

Table 1
Evaluation of the Home University

Factors in survey items	*Germany (N=75)*		*China (N=160)*		*Brazil (N=28)*		*USA (N=28)*	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Attractive institution	4.35	1.61	5.20	1.34	5.61	1.47	4.43	1.55
University offers exactly what I like (e.g., study content)	4.69	1.11	4.97	1.33	5.21	1.26	4.50	1.64
Stable and reliable study conditions (e.g., permanent contact partner)	5.28	1.07	5.46	1.32	5.18	1.36	4.64	1.59
Good tuition/learning/working climate	5.31	1.29	5.40	1.36	5.46	1.32	5.25	1.60
Friendly and competent lecturers	5.05	1.13	5.33	1.33	5.64	1.22	5.29	1.74
International orientation of the university (including summer school programs, semesters abroad)	5.40	1.43	4.89	1,41	4.21	1.50	4.54	1.64
Innovativeness of the university (e.g., modern, technical laboratories)	4.55	1.63	5.21	1.44	4.21	1.23	4.57	1.81

Usage of Relevant Tools in Learning

Table 2 shows the results of the students' frequency of use of different relevant technological tools for learning or studying. Messenger apps, search engines as well as the university's online libraries, and learning management portals were the most frequently used tools across the four countries. Learning apps and conference technologies seemed to be more important for studying in China and the USA, compared to Germany and Brazil. The Chinese students also indicated frequent use of social media portals, in contrast to the other countries. Especially in Germany, social media does not appear to be used as much in the context of higher education. One possible reason for this trend could be that China and the USA are very keen on using the newest technology inside and outside the classroom, whereas Germany and Brazil are still in the process of implementing technological tools in the classroom (Honal et al., 2018). These findings suggest that students from different countries use similar tools for learning STEM-related content, but also other study content.

Table 2

The Intensity of Usage of Relevant Technological Tools for Studying

Tools in survey items	*Germany (N=75)*		*China (N=160)*		*Brazil (N=28)*		*USA (N=28)*	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Online libraries from the university	4.48	1.68	4.81	1.84	4.18	1.93	4.46	1.69
Internet search engines (e.g., Google or Baidu)	5.67	1.17	6.03	1.34	6.21	1.10	4.96	1.84
Social media portal (e.g., Facebook or a similar portal)	3.43	1.91	4.98	1.73	4.29	2.05	4.39	1.81
Blogs (e.g., from professors)	2.57	1.63	3.76	1.81	3.32	1.94	3.64	1.81
Video channels (e.g., from professors)	3.59	1.95	4.13	1.61	3.21	1.93	4.21	1.77
Community/conferen ce technologies (e.g., Skype)	2.51	1.77	4.07	1.77	3.32	1.83	4.25	1.69
Cloud-based groupware for working together on tasks (e.g., Dropbox)	3.09	2.05	3.89	1.80	4.29	1.80	4.18	1.74
WhatsApp, WeChat and other services	4.93	1.89	5.72	1.57	5.46	1.50	5.46	1.64
Learning management portals from the university	4.13	1.97	4.46	1.53	5.11	1.77	4.21	1.66
Learning apps (e.g., language course)	2.81	1.96	4.97	1.53	3.75	1.96	4.64	1.50

University Learning Management System and Learning Apps

Table 3 shows the results of the participants' evaluation of their university's learning management system as well as learning apps in general. Overall, the university's learning management system were rated as "good", "innovative" and "user-friendly." The students also indicated that the system facilitated their learning. The Chinese participants rated their learning management system the best, whereas the German students gave the lowest ratings compared to the other three groups. The same differences were found in the evaluation of learning apps. Here, German students also seemed to be a bit more reserved towards this technology. In China, learning apps were attributed the highest value, whereas the Brazilian and American ratings was somewhere in between. Overall, the results indicated that the students saw a benefit in using apps for their learning.

Table 3
Evaluation of Learning Management System and Learning Apps in Higher Education

Survey items	*Germany (N=75)*		*China (N=160)*		*Brazil (N=28)*		*USA (N=28)*	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Learning management systemevaluation: very bad vs. very good	4.76	1.31	5.28	1.20	4.96	1.53	4.71	1.88
Learning management systemevaluation: very user-unfriendly vs. very user-friendly	4.44	1.41	5.29	1.21	5.21	1.37	5.04	1.55
Learning management systemevaluation: not very innovative vs. very innovative	4.27	1.43	4.85	1.40	4.29	1.61	5.04	1.71
Learning management systemevaluation: does not facilitate learning/ working significantly vs. does facilitate learning/ working significantly	4.49	1.20	5.10	1.38	5.00	1.52	4.68	1.83
Learning Apps evaluation: very bad vs. very good	4.96	1.75	5.55	1.41	4.89	1.57	5.18	1.77
Learning Apps evaluation: very user-unfriendly vs. very user-friendly	4.97	1.49	5.38	1.35	4.96	1.62	5.25	1.78
Learning Apps evaluation: not very innovative vs. very innovative	5.13	1.57	5.13	1.41	5.21	1.57	5.32	1.68
Learning Apps evaluation: does not facilitate learning/ working significantly vs. does facilitate learning/ working significantly	4.72	1.56	5.34	1.34	5.50	1.23	5.00	1.63

Communication with Lecturers

Table 4 shows the results of the students' use of different technological communication channels for communication with their lecturers. The channels that were used most frequently were text messages and e-mail. The Brazilian and Chinese students indicated to use text messages very frequently to communicate with their lecturers. The mean was slightly lower at the American university, whereas the German participants used this channel a lot less compared to the other groups. For communication via e-mail, the differences were not as apparent. Only the Brazilian sample reported a higher frequency of use than the others. The results also showed that face-to-face meetings still played an important role in communication between students and lecturers. Online meetings were a lot more common at the Chinese, Brazilian, and American universities than at the one in Germany. The situation was similar regarding the use of communication technologies in general. At the German university, e-mail and face-to-face meetings were noticeably the most important channels while students from the other three countries reported a higher frequency of use for most of the other technological tools (e.g., conference technologies and social media).

Table 4

Assessment of the Communication with Lecturers During Studying

Communication channels in survey items	*Germany (N=75)*		*China (N=160)*		*Brazil (N=28)*		*USA (N=28)*	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Discussions/meetings (online)	2.63	1.93	4.33	1.64	4.25	2.01	4.25	1.86
Discussions/meetings (offline)	4.40	1.90	5.00	1.50	4.39	1.83	4.21	1.69
Telephone conversations	2.80	2.01	3.41	1.75	3.32	1.93	3.14	1.72
Learning management portals from the university	3.63	1.98	3.91	1.62	4.93	1.56	3.75	1.58
Email	4.44	1.73	4.35	1.68	5.64	1.59	4.50	2.08
Text messages (e.g., SMS, WhatsApp, WeChat)	3.72	2.18	5.27	1.62	5.61	1.87	4.82	1.70
Community/conferen ce technologies (e. g. Skype)	2.07	1.59	3.46	1.86	3.14	1.80	3.86	1.80
Social media portal (e.g., Facebook, LinkedIn or similar portals)	2.37	1.77	3.67	1.87	3.57	2.01	4.04	1.91

Technological Competence of Self and Lecturers

Table 5 shows the results of the students' satisfaction with their level of technical competence and the lecturers' competence of using new tools for lecturing as well as with the information technology support provided at their university. Generally, the students indicated to be satisfied with their own as well as their lecturers' competence level. In particular, the Brazilian participants gave very high ratings on these items. The results also suggested that lecturers actively used technologies to support the learning process. Furthermore, the students from all four countries seemed to be rather satisfied with the information technology support provided by their universities. The German sample clearly showed the lowest levels of satisfaction while the Chinese students gave the highest ratings for these services. A possible explanation for this could be the higher investments of Chinese universities in information technology, which improved the quality of the offered technical support in contrast to the other countries (Honal et al., 2018). But, for the next years, the German government plans to increase the information technology budgets for universities to modernize their technical infrastructures and learning systems to create a better platform for offline- and online education. Such initiatives are needed to bring universities from different countries to a similar level of informative technology service and infrastructure and ensure equal chances for teaching and learning.

Table 5

Level of Satisfaction with Own and Lecturers' Technological Competence and Information Technology Support at the University

Survey items focus	*Germany (N=75)*		*China (N=160)*		*Brazil (N=28)*		*USA (N=28)*	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Own competence level when using technologies	4.89	1.12	4.94	1.26	5.68	1.16	4.39	1.99
Lecturers' competence level when using technologies	4.69	1.22	4.92	1.26	5.21	1.29	4.57	1.55
Degree to which lecturers used technologies to support learning	4.35	1.24	4.91	1.30	5.00	1.25	4.50	1.60
Quality of the university information technology service	4.13	1.36	5.10	1.41	4.68	1.47	4.64	1.70

Prior Educational Information Technology Background

Table 6 shows the results of the students' assessment of their use of technologies during their youth (age 13 to 18). Their ratings indicated that technologies were present during their high school education across all four samples.

Table 6

Experiences with New Technologies in Youth

Survey items focus	*Germany (N=75)*		*China (N=160)*		*Brazil (N=28)*		*USA (N=28)*	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Consciously used a computer, the internet or other new technologies for school homework	5.09	1.66	5.51	1.34	5.11	2.23	5.04	1.79
Parents supported use of computer, the internet or other new technologies (e.g., learning portal) for school-related obligations	4.40	1.75	5.33	1.41	4.68	2.16	5.14	1.56
Well informed parents about how to use a computer, the internet or other new technologies for the purpose of learning/receiving information	4.49	1.66	4.46	1.69	3.75	2.25	4.46	1.75
Use of computer, the internet or other new technologies (e.g., learning portal) during school for the purpose of learning/receiving information	4.56	1.73	5.58	1.36	4.61	2.45	5.21	1.66
Learned how to use digital media and new technologies (e.g., as a learning aid) in school	4.09	1.72	5.31	1.35	3.82	2.18	5.29	1.54
Communicated and cooperated with classmates via using digital media or other new technologies (e.g., learning portal) in school	4.83	1.61	5.36	1.43	4.32	2.39	5.14	1.82

For example, the use of the internet or other technologies for homework seemed to be very common. Nevertheless, the Chinese and the American students agreed more that they learned how to use digital media in school compared to the German and Brazilian participants. The results suggested that even though technologies were important for school education in all four countries they were more actively addressed in Chinese and American classrooms. Students from these two countries also reported higher use of digital media for communication with their classmates in school. A possible reason for this situation could be that the usage of modern technology in German and Brazilian schools is still not as popular as in China and the USA. For instance, a lot of German teachers focus on classical learning settings and prefer a low-tech version of their classrooms (e.g., only a smartboard, but no tablets for the pupils). This was a big problem in Germany during the Corona-virus lockdowns in 2020/2021 because not every pupil had access to a laptop or tablet to do online home schooling. This crisis showed that investments in new technology for learning are a 'must' and a gamechanger for every educational system across the globe.

Regarding the different fields in which the students were enrolled – business vs. technical/engineering study programs or mathematics – it can be stated that there were no significant differences among the students across the four countries. All students had to take technical or mathematics-oriented lectures as part of their study programs. Moreover, the current student generation is very keen on testing new technical tools and is open-minded for innovations in the classroom, such as the usage of artificial intelligence, virtual reality, or machine learning during studying. Therefore, it does not matter in which field the students are enrolled since they all enjoy new technological tools and innovative methods in the classroom when their needs are met. Nonetheless, the educator plays an important role to offer the right tool mix and in the right dosage to secure effective learning outcomes for the students. Only an efficient mixture of classical and new tools as well as modern approaches makes learning and teaching effective and joyful for all participants, also when STEM-related content is learned or is taught (Honal et al., 2018).

Conclusions and Implications

As fast as the world changes, the education landscape needs to shift in response. Education is evolving to nurture students to be more connected in their lives, engaged in class, and equipped for their future. This is a space where technology and pedagogy can work hand in hand to facilitate change - be that by providing teachers with tools to enhance their lessons, creating more fluid learning ecosystems, or transforming classrooms into innovative learning spaces of the future. The study showed that all students had a high usage level of new technologies and access to modern technological equipment. Comparing the status quo of new technology among the four countries, the USA and China are slightly ahead in this field as also noted by Fallon (2012) and Hansen (2011).

An implication of this study is that various new technological tools should be regularly used to teach students effectively and education should adapt and change as fast as the demand for information technology/STEM skills is growing and evolving (Baker, 2018). Moreover, educators must rethink the traditional way they teach and steadily integrate new ways of lecturing into their daily professional life. Several new trends and innovative methods, such as virtual reality in the classroom or the intensive usage of learning apps, should also be used by the teachers to increase the students' learning engagement. Teachers can also make the best use of technology in the classroom by developing their awareness of a range of digital technologies and considering carefully both how and why they can be used to support students' learning. Effective selection of software and devices is only one important part of effective teaching. The consideration of what learning will be achieved and how the technology may help is fundamental to its effective deployment. Applying learning science insights to academic education, educators can create a dynamic, digital, and hands-on learning experience that is flexible and relevant, developing the skills needed to power the digital economy (Adams Becker et al., 2018; Bull et al., 2016; Chalmers et al., 2017). But teachers will always play a core role in the classroom (Frezzo, 2017; Honal et al., 2018). They have a unique and personal insight into each learner's progress, serving as a role model and personal expert, and inspiring in a way that technology itself is not able to do.

The presented study results are limited because only a medium sample size was used and only four countries participated. In addition, the statistical analysis consisted only of comparison of means. However, these empirical findings give great insights into this new area of research and help to derive useful ideas and first recommendations for universities and educators.

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