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PAPER

Measuring Video Conferencing System Success in Higher Education: Scale Development and Evaluation

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ABSTRACT

The COVID-19 pandemic has placed great importance on video conferencing tools in delivering instruction at higher education institutions (HEIs). Increased interest in video conferencing tools for hybrid and fully online teaching is also expected in the post-pandemic period. The main focus of this paper is on the analysis of the BigBlueButton video conferencing tool by using survey data collected from students (N = 175) at a HEI at the beginning of the COVID-19 pandemic. The assessment scales for data collection in the survey were based on the DeLone and McLean Information Systems Success Model (D&M ISSM), as well as on the concepts of usability (US), cognitive involvement (CI), and design appeal (DA). The analysis of the assessment scales indicated their good internal consistency and reliability (using the Cronbach alpha and other indicators). A correlation analysis and factor analysis were performed to assist in developing a structural model of the relations between independent variables; system quality (SYSQ), information quality (INFQ), service quality (SERQ), US, CI, and DA; and the dependent variable intention to use (IU) the BigBlueButton video conferencing system. A structural model was developed and confirmed with the use of partial least squares structural equation modeling (PLS-SEM), and the explanatory power (R^2 value) of this model was .507 regarding the dependent variable IU the BigBlueButton system.

KEYWORDS

video conferencing systems, BigBlueButton, e-learning, survey, PLS-SEM, IS success model, usability (US), user experience (UX), COVID-19 pandemic

1 INTRODUCTION

According to the Our World in Data (OWD) portal [1], at the beginning of June 2023, the number of daily new cases of the SARS-CoV-2 infection (as a 7-day rolling average) for all of the world continents and in most countries of the world returned to the level of the early COVID-19 pandemic before May 2020, with less than 50 new reported cases of infection per million inhabitants. In addition, the number of confirmed daily deaths reported by the OWD portal [2] at the end of May 2023 dropped

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below 0.5 per million (as a seven-day rolling average) on all of the continents, being the same as that at the very beginning of the pandemic before March 15th, 2020. It must be noted that on December 31st, 2022, as a consequence of this substantial decline in the momentum of the COVID-19 pandemic, the OWD portal and the World Health Organization ceased world-wide monitoring of school closures [3]. On May 5th, 2023, the World Health Organization (WHO) [4] issued a statement that "COVID-19 is now an established and ongoing health issue that no longer constitutes a public-health emergency of international concern and has popularly been interpreted as the end of the pandemic.

An important indication that the pressure on the use of e-learning in higher education was significantly reduced because of the slowdown of the COVID-19 pandemic can be found in the results of the ACE survey, which is regularly conducted among the presidents of higher education institutions (HEI) in the USA [5]. Figure 1 shows the responses to one question related to online learning from the ACE survey conducted in February and March 2023. The responses were collected from 442 college or university presidents in the USA. They indicated that, regarding the proportion of three forms of undergraduate teaching at their respective institutions in the spring semester of 2023–(a) in person (or face-to-face), (b) hybrid (or partly in person and partly online), or (c) fully online—there had been only a slight increase in the hybrid (+ 6%) and fully online teaching (+ 4%) in relation to their pre-pandemic ratios from the spring semester of 2019.

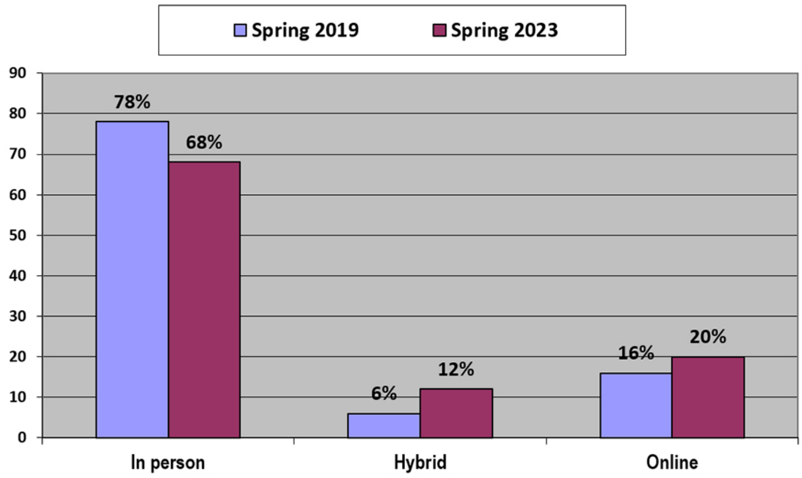

Fig. 1. Forms of teaching at universities in the USA in the spring semester of 2023 in comparison with the pre-pandemic spring semester of 2019

Source: 2023 ACE Survey of College and University Presidents [5].

On the other hand, a survey conducted at the beginning of the COVID-19 pandemic in 41 European countries [6] in the period from April 21st to May 3rd, 2020, indicated that 93% of the higher education students had their on-site (face-to-face) classes cancelled before or during the survey period. Also, according to the respondents to this survey (N = 9,180), the most frequent substitution for on-site teaching was online lecturing with real-time video (74.61%). Another survey [7], which was performed more globally among higher education students from 62 countries from May 5th until June 15th, 2020, found that 86.7% of respondents reported cancellation of their onsite classes due to the COVID-19 pandemic, as well as that online lecturing was predominantly in the form of real-time video conferences (59.4%). The only global survey at the beginning of the COVID-19 pandemic that investigated the most frequent applications used by HEIs was the one conducted in UNITWIN/UNESCO Chair Program host universities in April 2020 [8], which included 222 institutions from 67 countries. It revealed that the applications most frequently used by the surveyed HEIs were Zoom and Moodle learning management systems (both above 55%), followed by Skype (close to 50%), which were in turn followed by a very large variety of other applications.

The transition from predominantly on-site (face-to-face) academic education to predominantly synchronous online education conducted by means of video conferencing tools instigated an interest among numerous scholars and researchers worldwide in the evaluation of such tools and their comparison. Our analysis of related research papers revealed several relevant studies in that domain. A study conducted by Ospina García et al. [9] used the survey methodology with HEI teachers and students as subjects for comparative evaluation of nine tools with video conferencing functionalities (Zoom, Google Meet, Microsoft Teams, Skype, Jitsi, Webex, Big Blue Button, Blackboard Collaborate, and Lifesize). Their research revealed that Zoom, Google Meet, and Microsoft Teams were best evaluated, as well as that, after a multicriteria analysis, Jitsi also received the highest ranking due to its cost-benefit ratio since it was a freely available and open-source platform. Cavus and Sekyere-Asiedu [10] performed a detailed evaluation of the features of seven video conferencing platforms in the context of their educational use during the COVID-19 pandemic: Google Meet, Microsoft Teams, GoToMeeting, Cisco WebEx Meetings, Zoom Meetings, ClickMeetings, and BigBlueButton. Their recommendation was that, when making choices about the most appropriate video conferencing platform(s), teachers should carefully examine the diverse beneficial attributes of such tools while also taking into consideration their students' characteristics and course requirements.

According to the *2023 T3/Inside Information Advisor Software Survey* performed by Veres and Bruckstein [11], the worldwide market share leaders in video conferencing software were Zoom (57.2%), Microsoft Teams (24.6%), GoToMeeting (9.3%), Google Meet (6.3%), WebEx (6.10%), RingCentral (4.3%), FaceTime (2.0%), and Skype (1.2%). However, it must be emphasized that the use of video conferencing tools in higher education implies specific learning opportunities and challenges [12]. An interesting point can be made here: even though, after the onset of the COVID-19 pandemic, Zoom was the most frequently mentioned video conferencing tool in research papers related to higher education, BigBlueButton was actually the most popular open-source virtual classroom software, with both potential advantages and challenges regarding its pedagogical use [13] and technical implementation issues [14]. At HEIs with an adequate IT support service, the use of BigBlueButton was preferred because of its greater potential for customization and no licensing-related limitations regarding the number of virtual rooms, hosts, or duration of educational sessions.

The use of the Zoom video conferencing tool in the academic environment has been researched in the theoretical context of the technology acceptance model (TAM) [15], with perceived usefulness having the greatest influence on behavioral IU Zoom. Another study [16] used the unified theory of acceptance and use of technology 2 (UTAUT2) model and revealed that work-life quality and performance expectancy, as predictor variables, were most related to students' continuous IU Zoom for e-learning as a criterion variable. It must be noted that our study will focus on the BigBlueButton video conferencing system and the use of the DeLone and McLean Information Systems success model (D&M ISSM) (for a recent critical analysis of this model, see [17]; for a review of research in the educational context, see [18]).

The UNESCO survey [19] that dealt with the issue of disruption in higher education, conducted in the period from December 2020 to February 2021 among decision makers in higher education from more than 50 countries, revealed that most of these countries were in need of (a) "improvement in the infrastructure and availability of devices for online/distance learning," as well as (b) "guidelines/tools/teaching and learning materials to develop online/distance learning." The open-source BigBlueButton video conferencing system, which can be easily integrated into the most popular open-source moodle learning management system (LMS), can be viewed as one of the solutions for fulfilling this world-wide necessity, especially in low-income countries. Even though most of the restrictive measures related to the previous waves of the COVID-19 pandemic are not anticipated in the near future, it is opportune for HEIs to consider various e-learning technologies or their combination for sustainable long-term solutions that would provide the highest benefits to students, instructors, and IT support staff, as well as facilitate greater flexibility in teaching in the post-COVID-19 period.

2 DELONE AND MCLEAN INFORMATION SYSTEMS SUCCESS MODEL

The D&M ISSM was first presented in 1992 [20] and 1993 [21], with a revision in 2002 [22]. In 2003, the authors of this model [23] provided a concise explanation of their motives and context for its creation, as well as an overview of the first 10 years of its critique, improvements, and adaptations. In 2008, Peter, DeLone, and McLean [24] performed a review of papers related to information systems (IS) success published in the 1992–2007 period. In this review, a detailed explanation of the six constructs or variables related to the D&M ISSM (system quality (SYSQ), information quality (INFQ), service quality (SERQ), service use, user satisfaction, and net benefit) was provided with citations from the literature regarding the confirmation of numerous expected pairwise relationships between those variables (for instance, SYSQ → user satisfaction; SERQ → service use, etc.). A meta-analytic evaluation of pairwise relationships among variables of the D&M ISSM was performed in 2009 by Petter and McLean [25], and the following associations were most firmly established when the number of studies reporting the association (minimum 9–31) and the meta-analytic effect size (.48 – .65) were used as criterion for a high level of relationship: user satisfaction → IU (9studies/.65), net benefits → IU (14 studies/.55), system quality → user satisfaction (17 studies/.54), INFQ → user satisfaction (10 studies/.53), user satisfaction → net benefits (31 studies/.52), SYSQ → IU (12 studies/.48). The fact that the D&M ISSM persists to attract the interest of researchers has recently been confirmed by Rahayu and Setiyani [26], who found that since 2010, the number of papers using this model published annually has been continuously increasing.

As mentioned earlier, a recent systematic literature review [18] indicated (a) that the D&M ISSM is very frequently used for research in the educational context, especially regarding implementations and applications of online learning tools; (b) that the hybrid/extended D&M ISSM is the version of the model most often used in research; and (c) that for research purposes, the variables from the D&M ISSM were most frequently integrated with those from the TAM, expectation-confirmation model of IS continuance, task-technology fit model (TTFM), and unified theory of acceptance and use of technology (UTAUT). Another recent meta-analysis published in 2021 [27], which investigated the fields of e-learning in which the D&M ISSM was used, revealed that (a) it was rarely applied for the use of video conferencing systems in e-learning, (b) most of the expected relationships among the D&M ISSM variables were confirmed, and (c) some of the associations among the D&M ISSM variables were dependent on user types—student, teacher, or employee.

In the continuation of this paper, the revised D&M ISSM will be used in combination with selected constructs from other theoretical models and in relation to the use of the BigBlueButton video conferencing tool for educational purposes (e.g., as a virtual classroom).

3 RESEARCH GOALS

In the e-learning context, the studies that utilize the D&M ISSM encompass various indicators, including IS success, net benefits, impact at the individual or organizational level, and, especially, outcomes such as effectiveness. However, in approaches to research that extend the D&M ISSM in the context of education, it has not been uncommon to include additional aspects of technology acceptance and factors related to the continuity of its use [18]. Our study will combine user-centered and student-centered factors with the D&M ISSM variables in examining the IU the web-based video conferencing tool BigBlueButton. In our study, additional variables beyond the utilitarian aspects of BigBlueButton use will be covered. Since the D&M ISSM focuses primarily on the utilitarian (pragmatic) aspects of user satisfaction [28], in our study we have also included two constructs that are broadly related to user experience (UX), namely, (a) one aspect relevant for effective student learning engagement named cognitive involvement (CI) and (b) one hedonic aspect of the use of web applications named design appeal (DA). The measurement instrument designed for this purpose will be presented and evaluated in the continuation of this paper. According to Urbach and Müller [29], for the constructs from D&M's model and scales for their measurement, many similar counterpart constructs related to information systems characteristics and success exist that were developed by other researchers along with their corresponding measurement scales. The aforementioned authors conclude that the advancement of service-related information systems will facilitate the development of extensions and updates of the D&M ISSM.

The goals of our study are twofold: (1) to provide a brief overview of the scale design and validation process of a measurement instrument that extends the D&M ISSM model with several additional constructs; and (2) to investigate possible relationships between the variables of the proposed model in relation to students' IU the video conferencing system BigBlueButton as a specific example of web conferencing tools that are used in distance education.

4 OPERATIONALIZATION OF CONSTRUCTS

In our study, seven constructs will be operationalized: IU as a dependent variable, three independent variables from the revised D&M's model [22] (SYSQ, INFQ, and SERQ), as well as three additional dependent variables as constructs from TAMs and research related to exploring key factors in UX and intent (US, CI, and DA). The following section provides definitions of the selected constructs and clarifies the extent to which they are appropriate and relevant for investigating the success and effectiveness of video conferencing systems, keeping in mind students' intentions to use such systems in the higher education e-learning context.

Intention to Use. The IU construct is a common dependent variable in models that examine user behavior and how technology is used. IU represents the user's attitude toward the future use of a specific technology, as opposed to its actual use, which refers to the user's behavior. The notion of behavioral intention was introduced by Dulany [30] [31] in his theory of propositional control (TPC). According to Dulany, after people form a conscious intention for a certain behavioral response, such behavioral intention (BI), as a construct, has an influence on the real-world behavior that is actually performed. The TPC was followed by the theory of reasoned action (TRA), developed by Fishbein and Ajzen in 1975 [32] [33]. TRA tries to predict behavioral intention from the attitudes and norms of an individual. The theory of planned behavior (TPB) was built upon TRA and was first proposed by Ajzen in 1985 [34], who included the variable Perceived Control of the behavior that people would like to carry out as another predictor of behavioral intention. In 1989, Davis [35] developed the TAM, which is partly based on TRA but was particularly adapted for the prediction of BI in the specific field of acceptance and use of technology by introducing two antecedent variables: perceived usefulness and perceived ease-of-use. However, the currently most utilized concept for predicting BI in technology use is the UTAUT, which was developed upon extensive analysis of diverse related models and published by Venkatesh et al., in 2003 [36]. UTAUT was developed to predict not only IU but also temporally distant user behavior (e.g., the use of a particular technology in hours or days in the future). According to Venkatesh et al., the UTAUT model assumes that behavioral intention is influenced by variables such as performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC). It must be noted that, even though both the TAM and UTAUT models have been renewed and supplemented by their authors and other researchers, the variable BI (or IU) has remained part of the more recent and advanced models.

Information quality. The INFQ dimension of D&M's IS success model refers to the output quality of the observed system. Petter et al. [25] highlight accuracy, relevance, timeliness, understandability, completeness, and US as common attributes of INFQ as a research construct. These attributes are often used in relation to the management of data and information in a system or its related functions (e.g., content management), as they reflect the representation of content in a format that is convenient and desirable for the end user [37]. In research, INFQ is often measured as part of the construct of user satisfaction, as it has a strong influence on it [38].

Service quality. In the early 2000s, as technology and related information systems were rapidly evolving, the authors of the original D&M ISSM recognized the need for a new variable in the model, which they named SERQ [23]. This variable was introduced to capture and measure IS characteristics or attributes related to IT service delivery or support to different user groups at the individual or organizational level. SERQ is a measure of the IS success and refers to the *"support of users by the IS department, often measured by the responsiveness, reliability, and empathy of the support organization."* [25, p. 161]. Measures of SERQ have their roots in the SERQUAL model [39]; the model was later advanced to the E-S-QUAL model to include electronic service [40]. Researchers have recently adapted the measure of SERQ in terms of its relevance to the end users of online tools. For example, in measuring e-portfolio success in the higher education context, Balaban et al. [41] included SERQ related attributes such as integration with other online tools, help features, and responsiveness.

System quality. The SYSQ variable (as a characteristic of the IS concerning its hardware and software) was included in the first version of the D&M ISSM introduced in 1992 [20] and remained part of it in its second (revised) version presented in 2002 [22]. The SYSQ variable was initially [20] associated with IS attributes such as system and data accuracy, ease of use, ease of learning, usefulness of features and functions, flexibility, reliability, sophistication, and integration of systems. The relations of the SYSQ variable with other D&M ISSM variables such as use, user satisfaction and net benefits were discussed in detail by Petter et al. in 2008 [24]. These authors more specifically defined this variable in terms of ease of use, flexibility, reliability, ease of learning, intuitiveness, sophistication, and response time. The overview of literature performed by Urbach and Müller in 2012 [29] revealed the following additional measures of SYSQ: access, convenience, customization, efficiency, and interactivity. Finally, it must be noted that the relations between SYSQ and the variables IU, user satisfaction and the actual use were confirmed in a meta-analysis performed in 2015 by Ramírez-Correa et al. [42].

Usability. The ISO/IEC 25000 standard, also known as system and software quality requirements and evaluation (SQuaRE) defined US as *"the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions"* [43, pp. 5]. In our study, the subjective experience of US evaluation refers to perceived usability. Among the popular and widely used methods for measuring perceived usability is the system usability scale (SUS), developed by Brook [44]. One of the reasons for its extensive application is its simplicity, as well as its reliable psychometric properties and an acceptable number of items—10 in total—which makes it practical for both researchers and experts in the field of human-computer interaction (HCI) [45]. In studies of higher educational technology systems, the SUS has been widely used to assess the perceived usability aspects of the use of various mobile applications, Internet platforms, multimedia, and affective tutoring systems [46]. Originally, the SUS was designed as a single-factor measure of perceived usability, but the testing of this scale indicated a two-factor structure that encompasses US and learnability [47]. In our study, a shortened version of the SUS was used that combined items related to learnability and ease of use. The construct, learnability, indicates how user-friendly the system is and whether users are able to learn the system's functions and solve problems without difficulty while they are at the initial stage of its use [48]. Perceived ease of use refers to the belief that the technology or system is effortless to use [49]. Given that in 2020, due to the COVID-19 pandemic, most students were for the first time exposed to intensive online instruction delivered predominantly synchronously via web conferencing tools, the authors find it opportune to include an additional scale of US in the measurement scales related to D&M's model [22] (SYSQ, INFQ, SERQ, and IU). This would enable the investigation of the perceived ease of use of the BigBlueButton video conferencing tool. It must be noted, however, that some of the recommendations listed when using the SUS in technological education research were to optimize the items and include more appropriate statements that measure attributes not covered by the SUS [46].

Cognitive involvement. The construct of CI is used in marketing and consumer behavior research, where it can be defined as *"a concern with the functional information content of a communication"* [50]. A similar construct named cognitive engagement was introduced by Corno and Mandinach in 1983 [51] regarding classroom learning motivation. Fredrics et al. [52] stated that "cognitive engagement can range from simple memorization to the use of self-regulated learning strategies that promote deep understanding and expertise" and "incorporates thoughtfulness and willingness to exert the effort necessary to comprehend complex ideas and master difficult skills." However, it must be emphasized that Green [53] defines cognitive engagement in classroom settings as the "type and degree of cognitive strategy use, the use of self-regulatory processes, and the degree of effort exerted," which is a considerable extension of the cognitive engagement concept that will not be addressed in this paper. An interesting concept, very similar to our conceptualization of CI, was introduced in the literature in 2000 under the name cognitive absorption (for detailed elaboration of the cognitive absorption construct and its initial measurement scale, see [54]). A thorough, in-depth empirical analysis of the cognitive absorption construct and measurement scale was performed by Deng et al. in 2010 [55]. According to Saadé and Bahli [56], cognitive absorption can be defined as a general state of deep mental involvement with the following attributes: (a) dissociation in the perception of time flow, (b) focused immersion in an activity, and (c) enhanced enjoyment. For the purpose of our study, the term "cognitive involvement" was used as a label for such a construct.

Design appeal. The DA attribute was frequently mentioned in scholarly papers on marketing and visual design of various products (cars, television sets, textiles, architecture, etc.) but seldom elaborated in detail as a research construct. In the IT services sector, the term DA is related to the desirability attribute of the UX and also partly to the satisfaction dimension of US, both of which extend the concept of US beyond efficiency, effectiveness, engagement, error tolerance, and learnability. Still, DA as a construct and an independent variable in our study can be partly associated with the hedonic aspects of using technology and linked to quality attributes such as enjoyable, exciting, pleasant, and interesting [57]. In the field of interaction design, various other UX goals (i.e., attributes) were articulated that are associated with a diverse range of positive emotions [58, pp. 22]: satisfying, entertaining, helpful, motivating, challenging, enhancing sociability, supporting creativity, cognitively stimulating, fun, provocative, surprising, emotionally fulfilling. The purpose of a system or technology is not exclusively hedonic, on the one hand, or motivated by utility and productive use, on the other, since a sense of enjoyment can be realized simultaneously with the utility and productivity of a system [59]. It must be noted that the value of a hedonic system is a function of the degree to which the user experiences fun when using the system [57]. Therefore, the dominant design objective of hedonic systems is to encourage prolonged use, and for such systems, perceived enjoyment could be a stronger predictor of behavioral IU than perceived usefulness [57]. In the case of our study, which focused on investigating students' IU the BigBlueButton web conferencing system, the measurement scale for DA included items related to visual appeal, curiosity, and creativity, which is also similar to the operationalization of UX through cognition, affect, and meaning in combination with the D&M ISSM [28]. BigBlueButton was an essential medium for communication between instructors and students as well as knowledge transfer during the lockdown of universities and the transition to fully online or hybrid teaching due to the COVID-19 pandemic. If this tool were to be used by instructors (teachers) in class in a way that encourages students' curiosity and creativity, it could be perceived not only as a useful technology but also with a new added value associated with at least some hedonic aspects of technology use [60].

5 RESEARCH METHODOLOGY

5.1 Procedure

The data collection for the study that is presented in this paper was performed during the first year of the COVID-19 pandemic at a HEI in Central and

Eastern Europe. Due to the closure (lockdown) of HEIs and the need for social distancing during the first year of the COVID-19 pandemic, most of the teaching at this HEI was performed using video conferencing tools such as BigBlueButton.

For the collection of responses from the subjects in our study, a Google Forms online survey was used that was comprised of demographic questions and items related to frequency and intensity of BigBlueButton use, as well as assessment scales that were designed to measure six independent variables and one dependent variable.

The number of students that were initially included in our study was 193, but after data cleaning, the final sample consisted of 175 participants whose responses were used for data analysis.

The BigBlueButton video conferencing tool was fully integrated as one of the functionalities ('plugins') of the Moodle system. The collected data was analyzed with SPSS software and Smart PLS. Before data collection with the online survey approval was obtained from the Ethics Committee.

It is important to note that the authors of this paper previously presented a much briefer conference report regarding the preliminary version of this study with a slightly different data set and less elaborated data analysis methods.

5.2 Instrument

A Google Forms online survey that was used for data collection consisted of introductory questions and assessment scales. The data collected by introductory questions included demographic data (year of study, gender, etc.), the number of courses in which the BigBlueButton tool was used, the weekly frequency and average time of the use of the BigBlueButton tool in the previous 6–7 weeks, as well as the devices (computers, smartphones, etc.) that were used for attending BigBlueButton video conferences. The constructs and variables measured by the assessment scales included six independent variables (SYSQ, INFQ, SERQ, US, CI, and DA) and IU as a dependent variable. These constructs were described in more detail in the previous section of this paper, and in this section, their sample items will be presented.

It must be noted that before the data analysis in this study, the initial versions of the assessment scales were slightly modified to improve internal scale consistency (measured by the Cronbach alpha coefficient). Also, several items were excluded after a detailed inspection regarding face validity and item redundancy. The final versions of the assessment scales and their corresponding items for which the data was collected and used in our analyses are presented in Appendix A. Most of the items were adapted from scales that were used in various published studies by other authors, but some were created solely by the authors of this paper. It must be noted that the first goal of our study was to provide a brief overview of scale design and validation of a measurement instrument that extends the D&M ISSM model with several additional constructs. For illustration purposes, only the sample items of the final versions of assessment scales that were used in our study are presented below, as well as the corresponding Cronbach alpha coefficients (that are also listed in Table 5), while the complete assessment scales can be found in Appendix A.

The SYSQ scale measures a key variable from the D&M ISSM, and in its final version, it consists of six items (with a Cronbach alpha of 0.787). Two sample items from this scale are: "I find BigBlueButton flexible for most of the things I needed to do with it." and "The BigBlueButton system works fast enough and can be used without much waiting for all the necessary functionalities that need to be activated."

The INFQ scale has also been designed according to the D&M ISSM, and it consists of six items (with a Cronbach alpha of 0.871). The sample items from this scale are: "By using the BigBlueButton system, an easy and successful exchange of information between different users was achieved." and "The BigBlueButton system enabled the relevant information to be well understood."

The SERQ scale measures the third construct of the D&M ISSM, and its items were developed with reference to several sources. After correction for consistency and redundancy the final version of this scale consisted of six items (with a Cronbach alpha of 0.846). These are two sample items from this scale: "I felt that I could rely on the BigBlueButton system to obtain or exchange information that is personally important to me." and "The educational processes in which I participated were very well supported by the BigBlueButton system."

The US scale was developed mostly by selection and adaptation of items reported in published evaluations of US measures. After the exclusion of unclearly formulated items that were present in the initial version of this scale, the final version consisted of six items (with a Cronbach alpha of 0.792). Here are two sample items from the final version: "I mastered the use of the BigBlueButton system without difficulty." and "I think that different functionalities in the BigBlueButton system are well integrated."

The CI scale was developed predominantly having in mind the operationalization of this construct in the previous section of this paper and cognitive absorption as an element of UX research. After the correction regarding item content redundancy, the final version of this scale consisted of six items (with a Cronbach alpha of 0.854). Two sample items for this scale are: "When using the BigBlueButton system, I was able to keep my attention and interest longer than with other online teaching systems." and "When using the BigBlueButton system, I feel as if I am immersed in the communication and information I receive through it."

The DA scale was constructed according to the literature on desirability and satisfaction attributes in the field of UX, as well as, in particular, on the hedonic aspects of using technology and facilitation of positive emotions by means of visual design and interaction design. The final version of this scale consisted of seven items (with a Cronbach alpha of .838). The representative sample items are: "The user interface of the BigBlueButton system seems modern/contemporary." and "The BigBlueButton system encourages me to be more creative or innovative."

The IU scale is introduced as a potential dependent variable in several measures of IS success, as well in instruments that measure technology acceptance and use. The items for this scale were both selected from several related sources in literature and developed by the authors of this study. The final version of this scale consisted of seven items (with a Cronbach alpha of 0.889). Representative sample items for this scale are: "I hope that in the future I will be able to use the BigBlueButton system as much as possible." and "I will try to get to know and successfully master all the important functionalities of the BigBlueButton system for future use.".

To achieve the content validity of the previously listed measurement scales, the items (that are displayed in Appendix A) were mostly adapted from relevant sources in published literature such as the D&M ISSM, as well as other sources in scholarly papers that are related to the main constructs in this study. For instance, the following research reports have listed similar items as those of the assessment scales in Appendix A: [15], [20], [22], [23], [28], [29], [35], [36], [37], [40], [45], [49], [52],

[54], [55], [57]. The wording of the original items was reformulated to better adapt them to the context of BigBlueButton web conferencing tool usage in higher education. However, several items were created by the authors of this paper to capture in more detail the previously operationalized variables as well as their potential association with the dependent variable, behavioral IU video conferencing tools in education. The item selection process was performed keeping in mind that, when developing a new measuring instrument, construct validity is determined by the results of empirical evaluation of the degree to which selected items measure the construct, as well as by how the construct is operationalized [61].

For all of the assessment scales, a five-point Likert rating scale was used, ranging from 1 (strongly disagree) to 5 (strongly agree). As mentioned above, the internal consistencies (Cronbach alpha coefficients) for all the assessment scales were in the range of .792 to .889 (see Table 5 in 'Measurement model assessment' of this paper), which can be considered a "fairly high" level of internal consistency [62].

5.3 Subjects

The convenience sample in our study consisted of full-time students who were enlisted at a HEI in Central and Eastern Europe. The students that were surveyed attended three different communication science courses that were delivered to them in studies in software engineering, applied information technology, and entrepreneurship, respectively. After data cleaning, the final sample consisted of 175 participants (86 male and 89 female). This is the distribution of participants belonging to particular age groups, shown in percentages: 31.4% were 18–19, 40% were 20–21, 44.0% were 22–23, and 3.4% were 24–25 years of age.

All of the students who participated in our study had previous experience in teaching and learning activities performed with the use of the video conferencing tool BigBlueButton. Also, they had extensively used Moodle courseware that was adopted in all courses at their HEI. The video conferencing tool BigBlueButton was easily accessible to them since it was integrated into Moodle courseware. The students in our study reported using BigBlueButton for various purposes like attending lectures (95%), seminars (97%), auditory exercises (34%), laboratory exercises (33%), as well as for students' presentations and project reports (89%), consultations with teaching staff (51%), and online exams (29%). The BigBlueButton tool was reportedly used for 2–3 courses by 25% of the students, for 4–5 courses by 65% of the students, and for 6–7 courses by 10% of the students. Regarding the students' estimate of the frequency of use of the BigBlueButton tool (indicated per week during the previous 6–7 weeks), most of the students (69.1%) reported using this tool 3–4 times per week for all of the courses they attended in that period, followed by 1–2 times per week (reported by 15.4% of respondents), 5–6 times per week (stated by 12.6% of respondents), and 7 or more times per week (2.9% of respondents). Finally, 88.9% of the students declared that during the previous 6–7 weeks they had used the BigBlueButton tool for at least 3–8 hours per week. These findings indicate that the students who participated in our study (a) had experience with the use of the BigBlueButton tool for various educational purposes such as lectures, seminars, exercises, consultations, etc., (b) used the BigBlueButton tool for education in various university courses, and (c) had sufficient experience with the BigBlueButton tool both regarding the frequency and the amount of hours of its use in the 6–7 weeks preceding the survey administration.

6 RESULTS OF DATA ANALYSIS

6.1 Intercorrelation of variables measured by the assessment scales

Six independent variables (SYSQ, INFQ, SERQ, US, CI, and DI) and the dependent variable IU were measured by the assessment scales that were used in our study. The intercorrelations between these variables are presented in Table 1.

Table 1. Intercorrelation between the variables measured by the assessment scales (N = 175; Pearson correlation coefficients are presented; P < 0.01 for all correlations)

	SYSQ	INFQ	SERQ	US	CI	DA
SYSQ	–					
INFQ	.73	–				
SERQ	.71	.75	–			
US	.66	.68	.65	–		
CI	.48	.49	.57	.52	–	
DA	.51	.44	.52	.45	.63	–
IU	.43	.40	.46	.39	.61	.69

Note: *SYSQ – *System Quality*, INFQ – *Information Quality*, SQ – *Service Quality*, US – *Usability*, CI – *Cognitive Involvement*, DA – *Design Appeal,* IU – *Intention to Use.*

The results of the correlation analysis that are presented in Table 1 indicate that the dependent variable IU was in highest association with the variables CI (.61) and DA (.69). Also, relatively high associations (in the range from .71 to .75) were uncovered between the three central variables of the D&M ISSM:SYSQ, INFQ, and SERQ. Finally, the US variable was in highest association with the D&M ISSM variables, i.e., INFQ (.68), SQ (.66) and SERQ (.65). To investigate the associations within groups of variables in more detail several factor analysis were performed, the results of which are presented in the next section of this paper.

6.2 Factor analyses

A principal component factor analysis was conducted with the following variables: SYSQ, INFQ, SERQ, US, CI, DA, and IU. Only two factors were found in the initial unrotated factor solution with an eigenvalue greater than 1.0, and the use of the scree test also indicated a factor solution with two factors. However, to test and demonstrate the uniqueness of variables included in the factor analyses, a varimax rotation was performed on a solution with seven forced components, which equals the number of variables that are included in this analysis. The data regarding the forced solution with seven factors and varimax rotation are presented in Table 2.

The results of the forced factor analysis with a solution comprising seven factors (F1–F7) that are presented in Table 2 indicate a high probability that each of the scales included in this forced factor analysis measures, at least to some degree, a unique construct. All of the variables had a projection in the range of .797 to .890 on a single (representative) factor, and no variable had projections above .40 on any other factor that is shown in Table 2.

Table 2. Results of the factor analysis with a forced solution comprising 7 factors (N = 175; varimax rotation; factor loadings below .30 were omitted from the table)

	F1	F2	F3	F4	F5	F6	F7
SYSQ	**.829**						
INFQ	.309	**.810**	.300	.313			
SERQ		.317	**.797**				
US				**.861**			
CI					**.867**		
DA						**.855**	.338
IU							**.890**

Note: *SYSQ – *System Quality*, INFQ – *Information Quality*, SQ – *Service Quality*, US – *Usability*, CI – *Cognitive Involvement*, DA – *Design Appeal*, IU – *Intention to Use.*

In agreement with the Kaiser-Guttman rule that factors with eigenvalues that are greater than 1.0 should be retained as a criterion for the selection of the number of latent factors, a two-factor solution with a varimax rotation is presented in Table 3. This solution reveals two distinct factors, both of which comprise variables with loadings above .70 on the main factor and below .40 on the other factor. The first factor (F1) encompasses the following four variables: SYSQ, INFQ, SERQ, and US. The second factor (F2) is composed of these three variables: CI, DA, and IU. The results of this factor analysis have the following potential implications: (a) the first factor (F1) in Table 3 groups together the variables that are similarly experienced by the surveyed students and have rather small associations with the second factor (F2), which has the highest loading of .879 on the dependent variable IU; (b) the greatest associations within the second factor (F2) of the IU variable are with the two variables that are not included in the D&M ISSM, namely, with DA and CI. This means that, if the relations between the dependent variable IU and other variables included in this result of factor analysis in Table 3 are to be used for the creation of a structural model, greater importance regarding the influence on the dependent variable IU should be placed on DA and CI variables.

Table 3. Results of analysis with two retained factors (using the Kaiser-Guttman rule) (N = 175; varimax rotation; factor loadings above .70 are written in boldface)

	F1	F2
SYSQ	**.829**	.287
INFQ	**.882**	.220
SERQ	**.807**	.356
US	**.813**	.263
CI	.381	**.750**
DA	.291	**.839**
IU	.193	**.879**

Note: *SYSQ – *System Quality*, INFQ – *Information Quality*, SQ – *Service Quality*, US – *Usability*, CI – *Cognitive Involvement*, DA – *Design Appeal*, IU – *Intention to Use.*

The scree test (or scree plot), proposed by Cattell, is an alternative means for selecting the number of components in factor analysis. Having in mind the results of the scree test, the optimal number of factors would be two or maximum three for a factor analysis of seven variables that were included in our study (SYSQ, INFQ, SERQ, US, CI, DA, and IU). Accordingly, for the purpose of retaining additional information for the creation of a structural model, a forced three-factor solution with varimax rotation is presented in Table 4.

Table 4. Results of factor analysis with three factors (N = 175; varimax rotation; factor loadings above .70 are written in boldface)

	F1	F2	F3
SYSQ	**.851**	.334	.005
INFQ	**.874**	.183	.176
SERQ	**.793**	.298	.248
US	**.768**	.121	.441
CI	.291	.470	**.796**
DA	.301	**.841**	.192
IU	.196	**.863**	.237

Note: *SYSQ – *System Quality*, INFQ – *Information Quality*, SQ – *Service Quality*, US – *Usability*, CI – *Cognitive Involvement*, DA – *Design Appeal*, IU – *Intention to Use.*

The data that are presented in Table 4 again indicate a strong association between a group of variables associated with the D&M ISSM (SQ, INFQ, and SERQ) and US, according to their projections on the first factor (F1). Also, a new-third-factor F3 (in comparison to the results that are displayed in Table 3) contains a sole projection above .70 of the CI scale, which indicates that this variable should be differentiated from the variable IU. In fact, the variable IU had a very large projection of .863 on the second factor (F2) and, together with the variable DA, was best in describing this second factor. For the purpose of creating of a structural model, this indicates that the dependent (or criterion) variable IU could be to the greatest degree influenced by the independent (predictor) variable design appeal.

Further factor analysis was performed using the same variables as in Tables 2, 3, and 4 with forced solutions comprised of four and five principal factors and a varimax rotation. In the solution with four forced factors, the US variable was the only one with a large projection on a new-fourth-factor, in comparison to the data presented in Table 4. Finally, in the solution with five principal factors and a varimax rotation, the DA and IU variables dissociated to unique projections (these two variables projected on separate single factors), while large projections on one and the same factor were still retained for the main D&M ISSM variables (SYSQ, INFQ, and SERQ).

6.3 Partial least squares structural equation modeling

The partial least squares structural equation modeling (PLS-SEM) was performed with the help of SmartPLS 4 program in order to test the relationships between the variables in the research model and the hypotheses of the structural models.

PLS-SEM is a suitable and robust method often used in social science and information science research when the structural model is not simple and involves the analysis of complex relationships between observed and latent variables [63]. The PLS-SEM analysis was conducted in two phases. In the first phase, the reliability and validity of the measurement model were tested. The second phase involved testing the structural model and corresponding hypotheses, and it included the use of significance of path coefficients, effect size (f^2) values, and coefficients of determination (R^2).

Measurement model assessment. The items to measure the seven main constructs in our study (SYSQ, INFQ, SERQ, US, CI, DA, and IU) were partially adapted from existing literature or developed by the authors themselves. The next step in the evaluation of the measurement instrument was to check the convergent and discriminant validity of each construct. Therefore, for our PLS-SEM analysis, the evaluation of the reflective measurement model was performed using the Smart PLS software, the results of which are presented in the continuation of this section. The data shown in Table 5 indicate that Cronbach alpha coefficients for all research scales, as mentioned in the previous sections of this paper, were in the range of .787 to .889, which can be considered 'fairly high' (this categorization applies to coefficients ranging from .76 to .95, according to Taber's [62] recommendations for the development of and reporting of measurement instruments in educational science when indicating their acceptable internal consistency). In addition, according to the data displayed in Table 5, the values of the consistent reliability coefficient rho_A and composite reliability rho_C were above 0.7, which is in line with recommendations by Hair et al. [63]. Regarding convergent validity, all average variance extracted (AVE) values are above the minimum threshold of 0.5, which is accepted as a rule of thumb in the literature [63]. The aforementioned results indicate that each construct explains at least 50% of the variance of the corresponding items.

Table 5. Internal consistency and convergent validity of constructs (N = 175)

Construct	Cronbach's Alpha	Consistent Reliability (rho_A)*	Composite Reliability (rho_C)*	Average Variance Extracted (AVE)*
System Quality	.787	.831	.860	.511
Information Quality	.871	.884	.906	.619
Service Quality	.846	.875	.893	.586
Usability	.792	.804	.858	.504
Cognitive Involvement	.854	.855	.891	.579
Design Appeal	.838	.857	.891	.507
Intention to Use	.889	.893	.916	.609

Note: *Smart PLS was used to calculate consistent reliability (rho_A), composite reliability (rho_C) and average variance extracted (AVE).

It should be noted that in our PLS-SEM analyses, the Smart PLS software was further used for confirmatory factor analysis (CFA), which was performed to determine the factor loading of each item as an indicator of a corresponding factor. Although some indicators had a factor loading below the recommended value of 0.708 [63], they were not eliminated because their deletion did not substantially increase the internal consistency reliability or convergent validity of a construct in this study. When developing new measurement instruments, it is recommended that a less rigorous approach be taken when removing indicators since this may affect the content validity of the construct [64, pp. 77].

The next step was to test the discriminant validly of the research constructs. Discriminant validity refers to the degree of uniqueness of a particular construct compared to the other constructs in the model. For this purpose, the Heterotrait–Monotrait ratio (HTMT) of the correlations was calculated. The HTMT is described as the mean value of the item correlations across different constructs relative to the mean of the average correlations for the items measuring the same construct [63]. As presented in Table 6, the HTMT values for all constructs were below the 0.90 cut-off value, which indicates that discriminant validity was established between constructs [65].

Table 6. Heterotrait–Monotrait ratio of correlations–HTMT (N = 175)

	SYSQ	INFQ	SERQ	US	CI	DA	IU
SYSQ	–						
INFQ	.888	–					
SERQ	.878	.873	–				
US	.770	.820	.770	–			
CI	.603	.574	.679	.604	–		
DA	.665	.540	.642	.554	.744	–	
IU	.828	.467	.552	.457	.714	.783	–

Note: *SYSQ – *System Quality*, INFQ – *Information Quality*, SQ – *Service Quality*, US – *Usability*, CI – *Cognitive Involvement*, DA – *Design Appeal*, IU – *Intention to Use*; HTMT < 0.90.

The analysis that was previously conducted with the results presented in Table 6 shows that, regarding the indicators (e.g., items in assessment scales), the research constructs demonstrate good internal consistency as well as convergent and discriminant validity. Therefore, this final version of the measurement instrument was accepted for further structural analyses that consisted of seven assessment scales with a total of 44 items.

Structural model assessment and hypotheses testing. Validation of a structural model in PLS-SEM consists of determining the relationships between constructs based on regression equations. To evaluate the collinearity problems of the structural (inner) model, the variance inflation factor (VIF) was used. The VIF values for predictor constructs ranged from 1.000 to 2.983 for all constructs in the following structural model. It must be emphasized that VIF values that are less than 3 indicate that no collinearity problems were found among the predictor constructs and that the constructs are sufficiently diverse regarding their common variance [63].

Using the results of factor analyses with different numbers of forced factors (see Tables 3 and 4 for examples of a two-factor and three-factor solution), as well as the intercorrelation data between the predictor (independent) variables and the criterion (dependent) variable that are presented in Table 1, different versions of structural models for the interpretation of these data were formed and tested with the

PLS-SEM method. However, various complex structural models were not confirmed, and therefore a rather simple but 'robust' model with its hypotheses (H1–H8) is presented in Table 7 alongside the results of the hypotheses testing.

Table 7. Model path analysis and hypotheses testing using the PLS-SEM method (N = 175)

Hypotheses	Path Coefficient	p Value	t Value	f Square	Result of Testing
H1: Usability → Service Quality	.660	0	13.400	.771	Supported
H2: Usability → System Quality	.688	0	14.525	.897	Supported
H3: Usability → Information Quality	.701	0	16.430	.966	Supported
H4: Service Quality → Cognitive Involvement	.441	0	4.062	.110	Supported
H5: System Quality → Cognitive Involvement	.149	.165	1.387	.012	Rejected
H6: Information Quality → Cognitive Involvement	.054	.596	.530	.002	Rejected
H7: Cognitive Involvement → Design Appeal	.661	0	13.485	.775	Supported
H8: Design Appeal → Intention to use	.712	0	21.511	1.028	Supported

To perform the analyses and examine the relationships between latent variables (path coefficients) regarding hypotheses testing (H1–H8), bootstrapping in Smart PLS was performed. Bootstrapping involves subsampling with randomly drawn observations from the original dataset (with replacement). Full bootstrapping was performed according to the following parameters and recommendations in [66]: (a) the number of bootstrap samples was 10,000 and the number of cases was equal to the sample size; (b) the significance level was set to $p < 0.01$; and (3) a two-sided test type was used. Bootstrapping was performed to determine the statistical significance of the path coefficients.

For each path coefficient, the Cohen's f^2 measure of effect size was calculated and reported in Table 7. This measure indicates the relative influence of a predictor construct on an endogenous construct in terms of its explanatory power, i.e., the change in the R^2 when a particular construct is omitted from the model [67]. As a rule of thumb, the values of 0.35, 0.15, and 0.02 indicate a large, medium, and small impact on the endogenous construct, respectively [68]. As can be concluded from the data presented in Table 7, large impacts were uncovered between most of the constructs (for H1, H2, H3, H7, and H8); a small impact was revealed between the constructs SERQ and CI (H4); and no association was found in relation to H5 (SYSQ → CI) and H6 (INFQ → CI), where the f^2 values were 0.012 and 0.002, respectively, with $p > 0.01$.

To summarize, the results of the testing of the eight hypotheses (H1–H8) in our structural model, after bootstrapping that is presented in Table 7, indicate that a total of 6 out of 8 hypotheses were supported by the data analyzed with Smart PLS. The values of the path coefficients for the confirmed relationships between the constructs ranged from 0.441 to 0.712. The bootstrapping results show that the path coefficients for hypotheses H1, H2, H3, H4, H7, and H8 were statistically significant at the $p < 0.01$ level. The hypotheses (representing associations among research variables) that were supported are visually presented in the revised structural model that is shown in Figure 2.

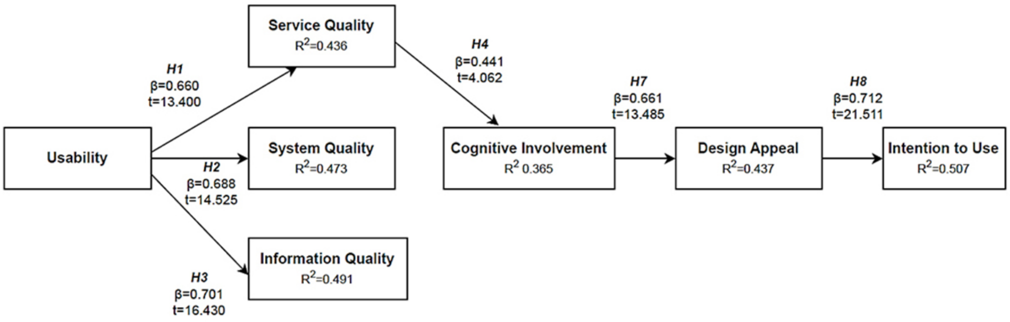

Fig. 2. The revised research model for the structural model after hypotheses testing; N = 175; p < 0.01

The final phase in the creation and testing of the structural model that would represent the interrelation among the constructs in our study and the relationships between the independent variables (SYSQ, INFQ, SERQ, US, CI, and DA) and IU as a dependent variable was to calculate the values of coefficients of determination (R^2) for the endogenous constructs. R^2 values in structural model testing represent the ratio of variance in a dependent variable that is explained by the independent variables and are used as a measure of the model's predictive accuracy [67]. R^2 values can be between 0 and 1, where values closer to 1 indicate greater explanatory power. It must be noted that R^2 values of 0.25, 0.50, and 0.75 are considered weak, moderate, and substantial, respectively [63]. The calculations of R^2 results for endogenous constructs are shown in Table 8, as well as in Figure 1 below the construct labels. The interpretation of R^2 values in Table 8 is that the determinants of five constructs (SYSQ, INFQ, SERQ, CI, and DA) have a weak explanatory power (in the range from .365 to .491), whereas the case of IU a substantial explanatory power that was revealed can be categorized as moderate since it slightly exceeded the critical value of 0.5. However, it is important to emphasize that R^2 values should be interpreted according to a specific study context and compared with similar studies using the same models or their variations [63, p. 11].

Table 8. Results of testing the explanatory power of the research model with the use of the coefficient of determination R^2 (N = 175)

Predictor Construct(s)	Endogenous Construct	R^2
US	SYSQ	.473
US	SERQ	.436
US	INFQ	.491
US, SYSQ, SERQ, INFQ	CI	.365
US, SYSQ, SERQ, INFQ, CI	DA	.437
US, SYSQ, SERQ, INFQ, CI, DA	IU	.507

Note: *SYSQ – *System Quality*, INFQ – *Information Quality*, SQ – *Service Quality*, US – *Usability*, CI – *Cognitive Involvement*, DA – *Design Appeal*, IU – *Intention to Use.*

7 DISCUSSION

The beginning of the COVID-19 pandemic in spring 2020 created a global interest in the educational use of synchronous video conferencing and online collaboration tools such as Zoom, Google Meet, MS Teams, BigBlueButton, and Jitsi (for their comparison see [9]). However, in 2021 and 2022, students in higher education started to gradually return to their on-campus instruction. In the USA, in the Spring 2023 semester, the interest of HEIs in hybrid and fully online teaching was only slightly higher than in the pre-pandemic Spring 2019 semester [5]. It can be expected that in the post-COVID-19 period more blended/hybrid and fully online teaching will take place [69], but with some adaptation from HEIs that would, for instance, be directed toward establishing systems for facilitation of online instruction by integrating technology and providing structural support and resources for more effective online education [70].

In our study, the focus was on the evaluation of the BigBlueButton video conferencing system in a higher education context. The main advantages of this platform are that it: (a) is open-source; (b) can be easily integrated with the open-source learning management system Moodle; and (c) does not require payment to a third party for establishing user's accounts with no limit to the duration of video conferencing sessions. For the evaluation of the BigBlueButton system, the theoretical framework of the D&M ISSM was used [20] [21] [22], which included the following constructs: SYSQ, INFQ, SERQ, and IU. According to a recent review of literature on the use of the D&M ISSM in the e-learning context [18], it was not uncommon to integrate the D&M ISSM with other theories and models such as the TAM, expectation-confirmation model of IS continuance, task-technology fit model, and UTAUT. In our study, the following additional constructs were supplemented to the D&M ISSM: US, CI, and design appeal.

The subjects in our study were university students enrolled in different study programs and courses at various years of study at a HEI in Croatia. All of the respondents had sufficient prior experience with the use of the BigBlueButton video conferencing system. The time of data collection was the beginning of the COVID-19 pandemic, when most of the respondents' courses were delivered online. The survey was also delivered online, and data cleaning was performed to exclude records with minimal or no variety in the type of response to survey items on a 1–5 Likert-type scale. The final convenience sample consisted of the data collected from 175 respondents.

In the first stage of data analysis regarding construct-related variables, the Cronbach alpha coefficients were inspected for all assessment scales, and after minor corrections, they were in the range of .792 to .889 (see Table 5), or 'fairly high' [62]. In the next step, correlation analysis was performed, which indicated that the dependent variable IU the BigBlueButton system had the highest association with CI ($r = .61$) and DA ($r = .69$) as independent variables (see Table 1). Also, factor analyses were performed with forced rotations (see 'Factor analyses' with Tables 2, 3, and 4) that also indicated a high association of IU with CI and DA. The correlation and factor analyses of the data also indicated a strong association among the D&M ISSM independent variables (SYSQ, INFQ, and SERQ; intercorrelations were in the range from .71 to .75 and the variables tended to project on a single factor), as well as between US and the aforementioned variables (correlations were in the range from .65 and .68).

After testing for internal consistency as well as the convergent and discriminant validity of the research constructs (see 'Measurement model assessment' and Table 6), a validation of alternative structural models was performed using PLS-SEM. However, complex structural models were not confirmed, and, as a best solution, a fairly simple model with its hypotheses (H1–H8) was proposed and tested (see 'Structural model assessment and hypotheses testing' and Table 7). Since hypotheses

H5 (AQ → CI) and H6 (INFQ → CI) of this model were not confirmed, a 'reduced' and final model was presented in Figure 2. Finally, when IU was observed as a dependent variable, the revealed explanatory power (R2 value) of the revised structural model (presented in Figure 2) with all of its independent variables included (see Table 8) was .507, which is slightly above the cutoff value of 0.5 for it to be categorized as 'moderate' [63].

According to the results of our detailed analyses of the data collected in our study, with regards to the associations of independent variables (SYSQ, INFQ, SERQ, US, CI, and DA) with the dependent variable IU in the BigBlueButton system, it can be concluded that the constructs CI and DA had a greater influence and predictive value for the dependent variable IU in comparison with the independent variables from the D&M ISSM. Therefore, for future investigations of the potential factors that influence the use of the BigBlueButton and other video conferencing systems, it is recommended that a variety of complementary constructs be used, not only those that would be associated with a single theoretical model such as D&M ICCM, TAM, UTAUT, or others. Because of their favorable internal consistency and predictive value in the study that is presented in this paper, the CI and DA scales will also be used in further studies by the authors.

It must be emphasized that the use of scales such as INFQ, CI, and DA for evaluation of communication tools and applications should not be viewed in isolation from the content and quality of communication itself. In other words, the interactions between the students (as evaluators of the BigBlueButton tool), the teacher, and the content of education that was presented via the BigBlueButton tool may have influenced the evaluations of the tool itself when such assessment scales are used. Therefore, it is important that the students as evaluators are selected from different study programs and years of study, as well as exposed to diverse courses and instructors, before their evaluation of BigBlueButton or similar tools is performed, as was done in our study.

8 LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

The limitations of our study could be related to the time of data collection, which was placed at the beginning of the COVID-19 pandemic and the first half of the year 2020, with lockdowns (school closures) at most educational institutions. However, for HEIs that do not have fully online study programs, the periods of school closures during the COVID-19 pandemic were an ideal time to collect such data from heterogenous students who were forced to temporarily attend at least several fully online courses. Another limitation regarding the interpretation of data collected from the period of transition to fully online instruction in the first half of year 2020 would be that the students could have viewed video conferencing technologies as a solution that enabled them to continue education in an imposed social distancing situation without the possibility for on-site teaching. This may have contributed to a slightly better overall evaluation of the tools that were used for such purposes.

In our future research, we may consider conducting a comparison of different video conferencing tools using the assessment instrument that was evaluated in our study (see Appendix A) in other environments and scenarios. Specifically, an assessment instrument could also be used from the perspective of instructors as creators of educational content with video conferencing platforms. Furthermore, qualitative methods such as interviews or focus groups could also be included in further research.

9 CONCLUSION

In scholarly papers, the broad educational characteristics of the BigBlueButton video conferencing tool were analyzed [13] or placed in the context of theoretical and practical frameworks such as UX models [71]. The BigBlueButton was also compared regarding its technical characteristics with similar tools such as Zoom [72] or several other video conferencing systems [9]. It must be noted that there are numerous comparisons of video conferencing tools such as BigBlueButton and Zoom available on the websites of HEIs, as well as educational technology and service providers.

The authors of this paper intensively used both BigBlueButton and Zoom at their HEI during the COVID-19 pandemic years and have been made aware of various advantages and disadvantages of each of the two systems. For institutions that can install BigBlueButton on their servers and have many instructors frequently using video conferencing to deliver education to groups of less than 100 students, BigBlueButton may be an opportune choice in the post-pandemic period. If this is not the case and video conferencing has to be used to simultaneously deliver instruction to very large groups of students (200 + or 300 +), or if only a small number of instructors are using video conferencing, alternatives to BigBlueButton could be considered. The research that is presented in our paper, as well as the assessment scales that are provided in Attachment A, may be helpful for such evaluation and decision-making purposes. As was previously mentioned, our study indicates that, if the D&M ISSM is to be applied in research aimed at technology use evaluation in educational settings, it would be a reasonable choice to supplement the D&M ISSM constructs with complementary assessment scales that are carefully selected from other theoretical models related to the acceptance and use of information technology.

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11 APPENDIX A

11.1 Self-assessment scales for measurement of main constructs

System Quality (SYSQ)

1. BigBlueButton is a reliable system that works without difficulties and errors.
2. I find BigBlueButton flexible for most of the things I needed to do with it.
3. In my experience, BigBlueButton is well designed for teacher-student interaction.
4. The BigBlueButton system works fast enough and can be used without much waiting for all the necessary functionalities to be activated.
5. I did not notice unexpected errors or interruptions in the functioning of the BigBlueButton system.
6. When using the BigBlueButton system, I did not expect problems related to my information privacy or security.

Information Quality (INFQ)

1. The BigBlueButton system enabled obtaining accurate and relevant information.
2. There was no loss of information when using the BigBlueButton system.
3. By using the BigBlueButton system, an easy and successful exchange of information between different users was achieved.
4. By using the BigBlueButton system, information was easily distributed.
5. The information in the BigBlueButton system had a suitable format considering its purpose.
6. The BigBlueButton system enabled the relevant information to be well understood.

Service Quality (SERQ)

1. There was no need to alert the IT support people because the BigBlueButton system was well maintained in technical terms.
2. The BigBlueButton system worked equally well regardless of the time of its use and the number of simultaneous users.

3. I think that the infrastructure for using the BigBlueButton system was generally very good.
4. I felt that I could rely on the BigBlueButton system to obtain or exchange information that is personally important to me.
5. The educational processes in which I participated were very well supported by the BigBlueButton system.
6. The BigBlueButton system is one of the better systems for e-learning (online teaching) that I have encountered so far.

Usability (US)

1. I mastered the use of the BigBlueButton system without difficulty.
2. I felt very confident using the BigBlueButton system.
3. It seems to me that most people would quickly learn how to use the BigBlueButton system.
4. I think that different functionalities of the BigBlueButton system are well integrated.
5. BigBlueButton's functionalities are easily applicable for my needs.
6. At all times, I felt that the BigBlueButton system would respond quickly and in the right way if I wanted to manage its functions.

Cognitive Involvement (CI)

1. Time seemed to pass quickly when using BigBlueButton.
2. When using the BigBlueButton system, I was able to keep my attention and interest longer than with other online teaching systems.
3. When using the BigBlueButton system, I feel as if I am immersed in the communication and information I receive through it.
4. When using the BigBlueButton system, other things and external distractions could not easily disrupt my attention and focus.
5. I had a lot of fun using the BigBlueButton system.
6. When using the BigBlueButton system, I felt that I had sufficient control over it.

Design Appeal (DA)

1. I like the visual design of the BigBlueButton system interface.
2. The user interface of the BigBlueButton system seems modern/contemporary.
3. The technical aspects of using the BigBlueButton system seem interesting to me.
4. I am particularly interested in the as yet untested/unexplored technical and practical possibilities of the BigBlueButton system.
5. The BigBlueButton system encourages me to be more creative or innovative.
6. I believe that my creativity and imagination can be more expressed when using the BigBlueButton system.
7. I was satisfied when I was able to use the BigBlueButton system.

Intention to Use (IU)

1. I feel happy when I find out that I need to use the BigBlueButton system again.
2. I hope that in the future I will be able to use the BigBlueButton system as much as possible.

3. I intend to use the BigBlueButton system with dedication whenever it is necessary in the future.
4. I will try not to miss any opportunity to use the BigBlueButton system in the future.
5. I would recommend others to use the BigBlueButton system.
6. I will try to get to know and successfully master all the important functionalities of the BigBlueButton system for future use.
7. I intend to expand my knowledge about the various technical characteristics of the BigBlueButton system as much as possible.

12 AUTHORS

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