Integrative Video Lectures

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Abstract. The article is devoted to the problem of optimizing the creation and use of didactically full-fledged versions of video lectures in the process of face-to-face and distance teaching. The distinctive features of the main variants of video lectures, which differ in didactic value and laboriousness of creation, are compared.

As a basic option, a video recording of a PowerPoint presentation with speech and graphic comments on the slides is considered. Video recording to the left of the screen (board) with a side view of the lecturer's shooting (standard profile version) is recommended for use when there is a shortage of space in the classroom. When using a professional video camera with powerful optical zoom, the preferred video lecture variant is a standard frontal one, filmed from the far end of the audience. The laborious didactically optimized editing of the video lecture is used to combine high-quality recording of visual materials of the basic version with any quality video recording of the teacher's actions.

A technique for creating integrative video lectures by means of video recording of the demonstration process of graphically commented slides is proposed, the design of which provides a special place for picture-in-picture insertion of video recording of the teacher's actions. The optimization of PowerPoint slide design options is argued, which ensures the effective creation of integrative video lectures. The highest ratio of "didactic quality / resource intensity" is achieved when creating integrative video lectures directly in the teaching process. The use of integrative video lectures allows you to minimize labor costs for creating media resources in the context of seamless integration of face-to-face and distance learning.

Keywords: video lecture, integrative video lecture, training video creation, distance learning, face-to-face teaching, work environment, Microsoft PowerPoint, HyperCam.

Introduction

The intensive development of network services during the second decade of the 21st century favored the formation of conditions for the modernization of the methods of creating and using video lectures. A modern video lecture is an audiovisual resource with a recording of the process of transmission of knowledge by a teacher, which pro-

vides didactic functions of primary perception, repetition, supplementation, and consolidation of information [1, 2]. Video lectures help students gain knowledge in case of missing classes. A structured video lecture with a table of contents [3, 4] promotes repetition of the material covered. The QR codes and hyperlinks to additional materials contained in the video lecture can be used to expand your horizons. The ability to instantly jump to the desired place in the video lecture by the URL and the network functionality of tagging any place on the frame with the organization of collective discussion are convenient in the processes of consolidation, systematization and generalization of essential information.

The technological evolution of hardware and software for the formation, transformation and transmission of audiovisual resources has led to a change in the set of main problems in the process of creating a professional video lecture [1, 2]. Ensuring the technical quality of the recording and organizing the distribution of video lectures have ceased to be limiting factors. In the third decade of the 21st century, the main problem is to ensure the didactic usefulness of video lectures, created in the conditions of academic mobility and lack of time during the period of seamless integration of fact-to-fact and online forms of education.

1 Historical Milestones in the Development of Video Lectures as a Genre of Educational Work

The professional use of video lectures in the Russian educational space began more than four decades ago. In 1974, lectures by the leading teachers at the North-West State Correspondence Technical University (SZTU, St. Petersburg) began to be broadcast on Leningrad television. Thanks to the technologies developed by the Research Institute of Television Education, the Modern Humanitarian University (Moscow) in 1998 began streaming production of video lectures in analog form, which were distributed via satellite systems and on VHS videotapes. At the same time, the University of South Florida (Tampa) began experiments to create digital video lectures using multimedia and network technology tools. Timely investments in the organization of the life cycle of video lectures ensured the formation of the richest educational video library at the Massachusetts Institute of Technology.

At the turn of the millennium, because of technological evolution, the distribution options for video lectures were supplemented by satellite channels, analog videotapes, digital physical media and Internet broadcasting. Since 2001, at the Lomonosov Moscow State University on the initiative of Ph.D. F.O. Kasparinsky launched scientific research on the adaptation of the evolving software and hardware tools for the creation and distribution of professional digital video lectures on CD and DVD, as well as on the Internet [1, 2, 4–8]. In 2005, video hosting sites appeared, the improvement of the functionality of which has reached a level that provides a didactically full-fledged use of network versions of video lectures with interactive tables of contents [4], teasers and targeted collective notes (https://vimeo.com). The global spread and improvement of information and communication technologies at the beginning of the second decade of

the 21st century created conditions for the dominance of Internet forms of video lectures as the most utilitarian form of video teaching method [2].

2 Didactic Completeness of Video Lectures

A didactically full-fledged video lecture should ensure the effectiveness of primary perception, repetition, supplementation, and consolidation of information [5]. The reliability of the information of a professional video lecture is certified by the authorship of the original lecturer. The value of the personal example of the lecturer and the information content of the video lecture for the education of personal qualities and the formation of competencies from the sum of competencies predetermines the attraction and retention of the student's attention. Practical experience shows that staged video lectures, as a rule, do not provide a high level of emotional impact of the teacher on students, which is characteristic of the synchronous process of communication with a live audience.

2.1 Illustrative Materials Used in Video Lectures

The technical execution of the video lecture should provide cognitive comfort and reliable accessibility in an arbitrary software and hardware environment. Visual materials should be formed in such a way as to provide a comfortable perception of information (texts, diagrams, photographs, animations, and video recordings) on the screens of any devices, from electronic boards to tablets and smartphones. Within the BYOD (Bring Your Own Device) paradigm, it is advisable to supplement visual materials with QR codes with hyperlinks to relevant primary sources of information. Thanks to QR codes, students get the opportunity to quickly familiarize themselves with the information they are interested in. Taking into account the likely use of visual materials not only in the process of synchronous face-to-face and distance learning, but also in the form of online PDF-publications for asynchronous self-study, it is advisable to associate pressure-sensitive hyperlinks to the corresponding resources with images of QR codes.

The effectiveness of the content creation of the training course was increased by universalizing the presentation of text and illustrations [9] in the primary presented visual aids of synchronous lessons and in the distributed version of the training course for asynchronous learning in a distance format. To create and conduct presentations, we recommend PowerPoint from the Microsoft 365 suite. It should be noted that the outdated version of PowerPoint from the Microsoft Office 2016 suite installed in electronic boards and teaching computers of state-funded institutions has a significantly reduced functionality (there is no selection panel for graphic tools and the ability to create integrative video lectures).

To ensure the optimal size of slides, it is recommended to use not standard parameters, but specially selected for utilitarian demonstration on screens of arbitrary size and in adaptive containers of website pages [10]. To do this, in the "Design" item of the top PowerPoint menu, select the "Slide size" button, select the "Adjust slide size ..." line from the drop-down menu, and then set the width of 27.093 cm in the pop-up window

at a height of 20.32 cm, which corresponds the classic aspect ratio of 4:3, optimal for displaying graphics and video on any screens [10].

It is recommended to place a decorative frame around the perimeter of the slide with a width of 3–5% of the slide size (see Fig. 1). This frame allows you to avoid problems of perception of content located on the periphery in the case of using the "overscan" mode, when the frame is displaced on outdated projection equipment, as well as in the case of rendering overlay peripheral navigation panels in video conferencing systems.

At the top of the slide, under the frame, it is recommended to allocate space for the frieze panel (10–15% of the slide height) containing the title and thematic symbols. The left side of the frieze contains the symbols of the course or the section of the grouping of information elements related to the slide. This design effectively identifies contextual content binding. The right side of the frieze is reserved for the symbol of the topic of the lesson. Heading text (chopped font, size 28–44) is placed in 1–2 lines in the center of the frieze (60–70% of the slide width).

Fig. 1. PowerPoint slide design in classic 4:3 format.

The lower part of the slide with a frame (relative height 25-30%) is recommended to be reserved for placement of the interpretation of terms (chopped font, size 20–24) and links to primary sources in the form of a QR code located on the left with an additional hyperlink. Experience has shown the utility of duplicating reference information, since in face-to-face classes, students use their devices with cameras (smartphones, tablets) to quickly go to primary sources by recognizing a QR code (utilitarian size is 20% of the slide height), and when using PDF versions of presentations, they prefer to click on the hyperlink associated with the image of the QR code.

Fig. 2. 16:9 widescreen PowerPoint slide design.

Fig. 3. Screenshots of identical frames of the presentation during the demonstration and at the end of the recording of the integrative video lecture.

The main area of the slide between the frieze and the term area is used to place illustrations (left) and text (right). The placement of illustrations and text in the main area of the slide varies depending on the specifics of the content.

The alternative 16:9 presentation design (see Fig. 2) is optimized for integrative recording of PowerPoint presentation demonstrations, in which graphic and speech comments of the teacher are supplemented by video recording of his actions (see Fig. 3). In this case, a wide-screen presentation template (16:9) with a width of 36.124 cm and a height of 20.32 cm is used. All guidelines for slide design are updated considering a 25% increase in width when selecting the "Fit to size" scaling mode.

To accommodate a video window with a current teacher, 25% of the right side of the framed lower area of all slides is reserved (contains a QR code and an interpretation of terms, occupies 25% of the total slide height). It is advisable to place a photo of the author of the presentation in the reserved rectangle with his name and QR code on the relevant portfolio (see Fig. 2 and Fig. 3).

2.2   Graphic Comments of Video Lecture Illustrative Materials

According to the students, the content of the presentation is better remembered if the speech comments are supplemented with graphical ones (highlighting key information, schematizing and complementing images, emotional markers).

In modern conditions (an audience with an electronic board and a potential network broadcast of events), the use of a material laser pointer is ineffective: the light spot of a weak laser (5–200 mW) does not stand out on the bright screen of an electronic board, and a powerful laser (2 W or more) damages screen and is potentially hazardous to the eyes.

The common way of using the cursor to focus attention is not optimal, because on the screen of the transmitting system it is poorly replaced (even in the form of a virtual laser pointer), and on the screens of receiving systems in some video conferencing systems (Teams, etc.) the cursor is replaced by a large one a red cross that can obscure the details of visual materials that are essential for the perception of students. When there is no need to focus on a certain section of the presentation slide, the teacher has to promptly move the cursor outside the presentation window so that it does not turn into a distractor of attention. Cursor movement can be done using touchpads (graphics tablet, teacher's touchscreen, wireless keyboard touchpad such as IPazzPort 19s).

After switching to the "Record Slide Show" mode, additional functionality of graphic commenting becomes available: an imitation of a laser pointer, a pen, and a marker. Using these tools with a mouse or graphics tablet is convenient for distance learning, when the teacher is sitting at the table. In full-time teaching, it is more convenient for the lecturer standing at the blackboard to use the touch panel of a portable keyboard or the stylus of an electronic board.

Using the touchpad in combination with a laser pointer simulator requires special skill to quickly remove the pointer outside the frame of the presentation at the moment when it is no longer needed, since the presence of the pointer in an irrelevant place on the slide is counterproductive. The "marker" tool allows you to select the desired fragments of the frame but is unsuitable for writing and drawing complex schemes. The most utilitarian option for graphic annotation is the direct use of the electronic board stylus in combination with the pen tool. The functionality of graphical presentation commenting in the PowerPoint version of the Microsoft 365 suite is much richer and more convenient (selection of tools and palettes) than in the standard version of the whiteboard application from the outdated Office 2016 suite. For this reason, it is more efficient to use the electronic board in the graphics tablet mode playing content from a USB-connected computer with the latest version of PowerPoint.

To create graphic annotations in the "Record Slideshow" mode, it is not necessary to activate the recording process, in which it is forbidden to move along a row of slides

in the opposite direction. If the recording process has been activated, after finishing the slide show and stopping the recording, the version of the presentation with graphic annotations should be saved in manual mode to be able to export the video later. The file size of the presentation with the recording of the demonstration can increase by an order of magnitude, which must be considered when choosing a medium. For example, a 40-minute presentation of 40 slides after saving a recording of the demonstration with voice and graphic annotations without turning on the webcam can increase in size from 10 MB to 100 MB. When the webcam is on, the storage space consumption increases by an order of magnitude. It is recommended that you turn off autosave to the cloud before showing the presentation, as this process can take a lot of time and do not fit into the schedule of full-time learning

For video conferencing, we recommend using the Cisco Webex, Skype, Teams, Zoom, and Discord services, where the teacher sees the content of his desktop on the screen in real time, rather than after it has been processed, as in OBS Studio. In the latter case, the teacher observes the appearance of his own graphic comments with an uncomfortable delay (1–2 sec), which inhibits the communication process. Broadcasting the desktop during the presentation with the webcam turned on allows students to simultaneously observe the teacher's work and the appearance of graphic comments on the slide.

2.3   Audio-Visual Recording of the Teacher's Actions

Video recording of a slide show with voice comments is not a didactically full-fledged version of a video lecture since it does not help to focus the attention of students on important elements of visual materials. The "Slide Show Recording" functionality of the program for creating and conducting PowerPoint presentations allows video recording of graphic comments synchronously with the speech accompaniment. Exporting such a recording to the mp4 video format allows you to obtain a basic version of the video lecture (see 3.1).

To form a didactically full-fledged version of a video lecture, it is necessary to record the teacher's actions, complementing the narration with gesture, emotional accents of facial expressions and possible visual demonstration of material objects. A standard version of a video lecture is a technical audiovisual recording of the lecturer's actions, addressing commentary on visual materials, in which the sound source is a directional or lavalier microphone. The shooting angle determines the version of the standard video – profile (see 3.2, example: https://vimeo.com/204236018) or frontal (see 3.3, example: https://vimeo.com/204236043). Creation of standard versions of video lectures is associated with significant resources (professional equipment [11], camera work). The most cost-effective option is an integrative video lecture, which provides a combination of video recording of the teacher's actions with graphic and speech comments of visual materials (see 3.5, example: https://vimeo.com/204235168).

2.4 Processing of Audio-Visual Recordings of Video Lectures

Basic versions of video lectures of the course "Natural Science" [11] – exported to mp4-format recordings of the demonstration process of PowerPoint presentations with speech and graphic comments on the slides - were directly published on the Internet video hosting Vimeo.com as part of the "Pro" quota 20 Gb / week) or were used for subsequent editing of didactically optimized versions of video lectures (see Fig. 4).
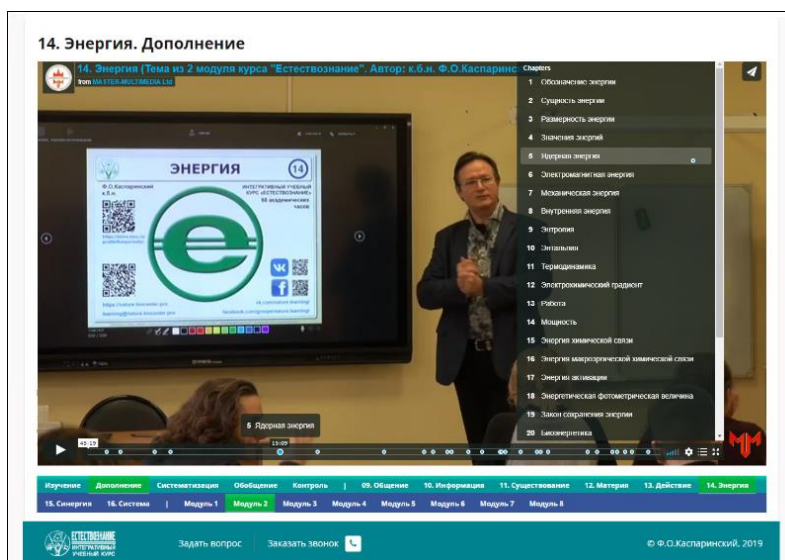

Fig. 4. Screenshot of a fragment of a web page with an embedded video lecture containing navigation menus.

Video recordings of face-to-face classes in MTS format and media data of online classes are processed using a graphics editor and exported at a resolution of 1920x1080 into mp4 video format, after which they are published on video hosting or used for editing didactically optimized versions of video lectures (see 3.4) .

2.5 Video Lectures Information and Navigation Service

Video lectures can be used with various service functionality. All audiovisual materials are specially adapted for online viewing on any user device. The video lecture player hosted on the Vimeo video hosting service can be inserted into the web page of the training portal with code that supports the responsiveness of the site template.

Example video player embed code for video lecture with 16x9 aspect ratio: <div style='padding: 56% 0 0 0; position: relative; '> <iframe src =' https: //player.vimeo.com/video/398614701 'allowfullscreen frameborder =' 0 'style =' position: absolute; top: 0; left: 0; width: 100% ; height: 100% ; '> </iframe> </div>.

When inserting a video lecture with a classic aspect ratio (4x3), the 'padding: 75% ' parameter is adjusted. After the video lecture is embedded in the code into a web page,

the functionality of overlay tables of contents and scroll bar labels with pop-up names becomes available, allowing you to non-linearly select the most interesting thematic fragment for further review without interruption (see Fig. 4 and example: https: // nature.biocenter.pro/videolecture/, point 2).

2.6   Collective Use of Video Lectures

On the video hosting Vimeo, you can watch video lectures in the mode of creating targeted notes and team discussion. Any user can focus everyone's attention on any element of the video sequence by setting a well-visible round blue mark. If necessary, the label can be moved in the frame field. When creating a mark, the corresponding item of the interactive table of contents of the audio-visual series is formed, clicking on which subsequently provides a transition to the desired frame and visualization of the marker. The length of the name and the number of items in such a table of contents is not limited. Users have the opportunity to comment on the text accompanying the tag, which creates a wonderful opportunity for collective discussion of the tagged content of the video in the framework of scientific, educational, business, public and any other activity. Any number of hyperlinks to third-party resources and other notes of the audiovisual series of the service can be inserted into a note, links to which are automatically generated in the address bar of the browser.

All participants in the discussion are sent email notifications of new notes and user reactions to them. To save their target notes and receive notifications when responding to them, users who are not registered on the Vimeo service must provide their e-mail address.

Each participant in the discussion can insert an arbitrary number of positional marks on any frame of the audiovisual series, in connection with each of which its own tree of notes and responses to them can be formed. This feature allows you to complement the use of video lectures with didactic functions of repetition, reinforcement, and control.

Updating the video lecture version results in a new set of targeted notes. For each version of the video lecture, its own set of collective notes is created. This feature of the functionality allows, by re-uploading to video hosting, to reuse one video recording to organize new discussions each training period. After clearing the discussion space, the previous sets of discussions are saved and can be used by the administrator after choosing to view the corresponding version of the video lecture.

Fig. 5. Screenshot of a snippet of a web page with targeted video lecture notes and team discussion.

3 Variety of Video Lectures

Currently, the main obstacle to the use of didactically full-fledged video lectures in the practice of everyday pedagogical activities is the resource intensity of their creation. During 2019–2020, in the process of creating an integrative course "Natural Science", 4 classical (see Fig. 6) and two integrative types of video lectures were tested, differing in didactic value and laboriousness (see examples: https://vimeo.com / showcase / 6184718).

Practical experience has shown the effectiveness of the sequential use of versions of video lectures: the first to connect to video hosting is the basic version of video lectures, created with the least labor costs. As the creation of perfect versions of video lectures, they are replaced by more primitive ones, interactive menus are created (see Fig. 4) and annotations with hyperlinks to relevant resources. It should be noted that the embed code and menus remain unchanged when replacing video lecture varieties.

3.1 Video Lecture of Basic Type

As a basic type of video lectures, you can consider a video recording of the PowerPoint presentation process with speech and graphic comments on the slides. The basic version of video lectures is attractive for minimal costs for Microsoft PowerPoint users, but limits the information space only to the mentioned presentation tool.

The high visual quality of the presentation of visual materials in basic versions of video lectures determines their preferable use in the absence of special equipment and

software for creating other versions of video lectures. The only equipment you need is a teaching computer (laptop, microcomputer, etc.) with a microphone. A cardioid microphone is recommended for better sound quality.
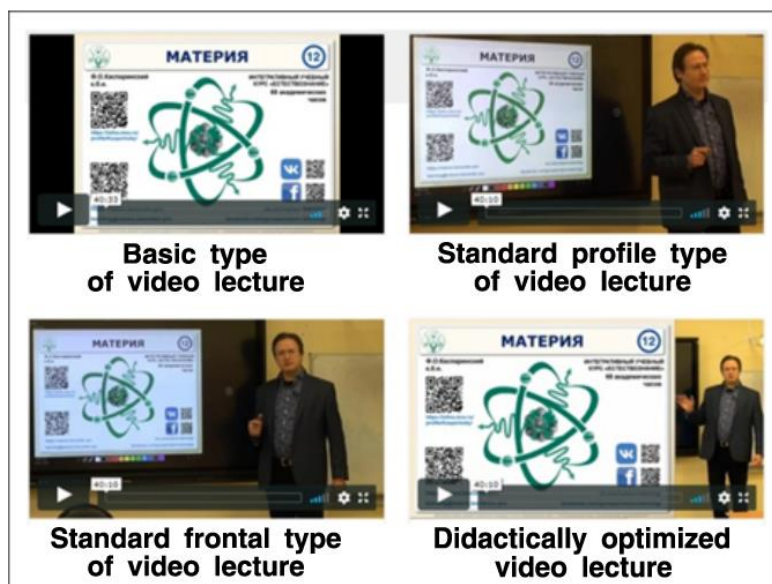

Fig. 6. Classic types of video lectures.

The technology for creating basic video lectures using the PowerPoint toolkit is simple (video tutorial for creating a PowerPoint application from the Office2016 suite: https://youtu.be/odjX5cf1B8U). When you switch to the recording mode of the demonstration of a PowerPoint presentation from the Microsoft 365 set (sequence of commands: "Slide Show" / "Record Slide Show"), the program automatically switches to full screen mode, in which the centered slide is framed by navigation service elements. On the sides are buttons for moving forward / backward, on top are buttons "Record", "Stop", "Repeat playback"; Notes, Exit Recording Mode, and Selecting Video and Audio Recording Sources. When the last-mentioned button is activated, a drop-down menu appears from which you can select the optimal devices. Below is the timer counter, buttons for selecting graphic tools (eraser, pen and marker), a palette, buttons for turning on / off the microphone, camera and displaying video from the camera). If a keyboard is available while working with a presentation, graphic tools can be switched by a keyboard shortcut: eraser – Ctrl + E, pen – Ctrl + P, marker – Ctrl + I. Note that PowerPoint from Microsoft Office 2016 does not have top and bottom bar tools.

It is recommended to activate one of the graphic tools immediately before the start of the presentation demonstration, because after recording is turned on, the transition to the previous slide is prohibited, and any click on the image without the graphic tool involved leads to the change of the slide to the next one. It should be noted that by

default the microphone is on, and the video camera is off. If the recording of the presentation demonstration is carried out in a remote format, then the microphone and video camera should not match the devices used for broadcasting.

When organizing video recording, it is recommended to pay attention to the fact that large screens (electronic board, etc.) have Ultra HD 4K resolution (2880x2160) and when connected to them, the presentation will be shown and recorded with an excessive size. To avoid inefficient resource consumption, it is recommended to switch the screen to FullHD 1080 p mode before starting the presentation and export the presentation at the same size.

To create a video lecture, you should export a presentation recording from a PowerPoint file into mp4 format (called by the sequence of menu commands: "File" / "Export" / "Create video". For slides with a design in accordance with the above recommendations (see 2.1), the content of the derived footage is well perceived at a frame size corresponding to the FullHD 1080 p standard (1080 vertical lines with progressive scan). If the size of the slides (height x width) corresponds to the aspect ratio of 4x3 (see Fig. 1), then when they are shown on the screen in landscape orientation with a size of 1980x1080, the video sequence is formed with a size of 1440x1080 at a frame rate of 30 fps.

When planning actions, it should be borne in mind that the process of forming video from a PowerPoint presentation is several times slower than processing ordinary video sequences, which significantly reduces the attractiveness of the basic version of video lectures.

3.2 Video Lectures of Standard Profile Type

To create standard versions of video lectures, you need high-quality video cameras, additional audio equipment, and time for processing data in a video editor. Standard versions of video lectures are attractive because they are not tied to the presentation program, which makes it possible for the teacher to use local and network media resources, as well as material objects (models, devices, etc.) as visual materials. It should be borne in mind that the placement and connection of a standard set of professional equipment (see Fig. 7) requires additional time, which may turn out to be unacceptable in conditions of high academic mobility. To get a high-quality video lecture, it is recommended to use professional video cameras in Full HD mode.

It is advisable to create video lectures of a standard profile type when there is a shortage of space for placing equipment and in conditions of a high probability of interference, such as moving students around the auditorium). The disadvantage of video lectures of the standard profile type is the trapezoidal distortion of the image of visual materials.

To form a video lecture of a standard profile type, a video camera is placed no more than 5 meters from the teacher to the left of the board at an angle of 45º (see Figure 7) and is used with a directional cardioid microphone. In the process of forming video lectures of the course "Natural Science" [11], a SONY HXR-NX30P video camera with a SONY ECM-XM1 directional cardioid electret microphone was used.

Fig. 7. Placement of video cameras for profile and frontal filming of a lecture in an auditorium with an electronic board.

3.3 Video Lectures of Standard Frontal Type

The standard frontal version of the video lecture compares favorably with the profile one due to the absence of trapezoidal distortions in the image of visual materials. To form a standard front-facing version of video lection, a video camera with high-quality optical zoom is required, which is located at the far end of the audience opposite the electronic board (see Fig. 7) and receives audio data from the lavalier microphone through a radio system from the transmitter and receiver. According to the results of student surveys, the standard frontal version of the video lecture is perceived better than the profile one.

In the process of forming video lectures of the "Natural Science" course [11], various options for transmitting the teacher's voice from lavalier microphones to the system were tested: via Bluetooth transmitters (OXLasers OX-304C) or UHF (ALLOYSEED, CORKT T1R1, SONY UWP- D16) connected to the corresponding receivers connected to the analog-to-digital converter (ADC) of a portable USB sound card (Vention CDKHB) connected to a microcomputer or electronic board (see Fig. 8). The latter option turned out to be preferable, since it made it possible to increase the recording volume and save the sound from electromagnetic interference, which intensifies as it approaches a computer or devices with Bluetooth interfaces using the 2.4 GHz range (keyboards, mice).

The choice of radio systems can be determined by the quality of sound transmission in accordance with the specifics of the taught discipline and the number of available communication channels, taking into account the schedule of the territorial organization of the educational process in the organization (sets of simultaneously operating equipment within a radius of 30–100 m must be tuned to different frequencies). When tuning UHF- (VHF-) radio systems in Russia, you must stay within the free range of 506 MHz.

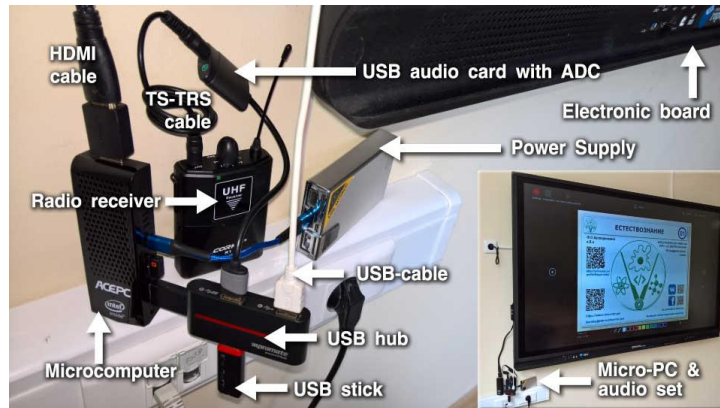For this reason, the use of the ALLOYSEED radio kit (200MHz-270MHz) is fraught with potential problems.

Fig. 8. Connecting a radio receiver, sound card and USB data carrier to the electronic board.

Economy-class systems (\$ 10– \$ 20) have a small number of allocated frequencies (4–16), which makes it difficult to use them in large teaching teams. The sound quality of the CORKT T1R1 radio system (620–690 MHz) turned out to be acceptable for recording activities with simple sound dynamics. Inexpensive radio systems to improve the quality of signal transmission in a limited bandwidth of the radio frequency channel use analog speech companders, which muffle hissing sounds and create unpleasant artifacts when transmitting rapidly changing signals (for example, clapping hands, sipping water, or ringing a bell). When communicating in languages with an abundance of hersing consonants, analog companders form the illusion of a speech defect. Expensive radio systems (\$ 200 – \$ 2000) use digital audio processors (DSPs, Digital Sound Processors) with companders that consider the complex dynamics of sound in both the transmitter and receiver. The microphone output of the radio receiver is connected with a TRS cable to the microphone input of a computer (sound card) directly or through the AUX Robotsky splitter, which allows sound recording to an external device in order to increase the reliability of the formation of a set of media data (see Fig. 9).

For insurance purposes, it is recommended to perform additional sound recording with an external dictaphone in wav format (PCM, stereo, 48KHz) through the microphone input connected to the Robotsky AUX splitter directly or with a device for suppressing acoustic feedback from the microphone. Backup audio data is used to replace distorted computer sound recordings (in case of system failures or errors when choosing the sound volume).

Fig. 9. Connection diagram of audio equipment for computer recording of video lectures in the classroom.

In large classrooms, it becomes necessary to organize sound amplification of the teacher's voice. A sound amplifying speaker system (speaker) can be connected to the headphone output of a radio receiver or a voice recorder (see Fig. 9). In the first case, a special microphone (Audio-Technica ATR3350 or Sennheiser ME 4-N) must be used to suppress the acoustic feedback of the microphone with the speaker. In the absence of such a microphone, the second option for connecting the speaker is used, in which an active filter is connected between the microphone output of the radio receiver and the input of the voice recorder to suppress acoustic feedback (SnapVox FBX-3 Feedback Howl Eliminator, etc.).

The choice of lavalier microphones can be determined by the characteristics of the audience (quiet, noisy or with sound reinforcement) and the style of the teacher's address to the audience. The problem of auditory noise in sound recordings of omnidirectional microphones is consistently minimized when moving to a range of directional (cardioid, supercardioid and hypercardioid microphones). However, the constant change in the orientation of the teacher's head (along the perimeter of the classroom and towards the blackboard) of the relative fixed directional microphone causes significant changes in the volume of the recorded sound. This problem can be solved by using two directional microphones mounted on opposite sides of the collar. Two microphones can be connected to one radio transmitter with a V-shaped cable, but this method reduces the overall volume of sound-recording due to the uncompensated competition of microphones for power supply. To overcome the power supply problems when combining the sound of two microphones, there are professional signal preamplifiers (Comica CVM-D03; Comica AD3; Saramonic-SR-PAX2) or radio sets of two or more transmitters connected to one receiver. The cost of the mixers ($ 50 – $ 150) is comparable to budget-class radio systems such as the XTUGA X-CM012 (550–580 MHz frequency range). Among radio systems with several transmitters in the middle price class ($ 250

– $ 500), in terms of price / quality ratio, Mailada WM-10 (frequency range 538-594 MHz) stands out.

The best lavalier microphones in terms of price / quality ratio turned out to be the omnidirectional microphone from the CORKT T1R1 radio set, as well as the MiCWL BC03 and Xgwth L777 cardioid lavaliers. When choosing radio transmitter kits and microphone connector options (TS – 2-pin, TRS – 3-pin, TRRS – 4-pin), it is important to check their compatibility with the microphone port of your computer or sound card (TRS or TRRS). TRS (Tip-Ring-Sleeve) connectors are compatible with sound cards of computers, cameras and video cameras, and TRRS-interfaces (Tip-Ring-Ring-Sleeve) are adapted for smartphones.
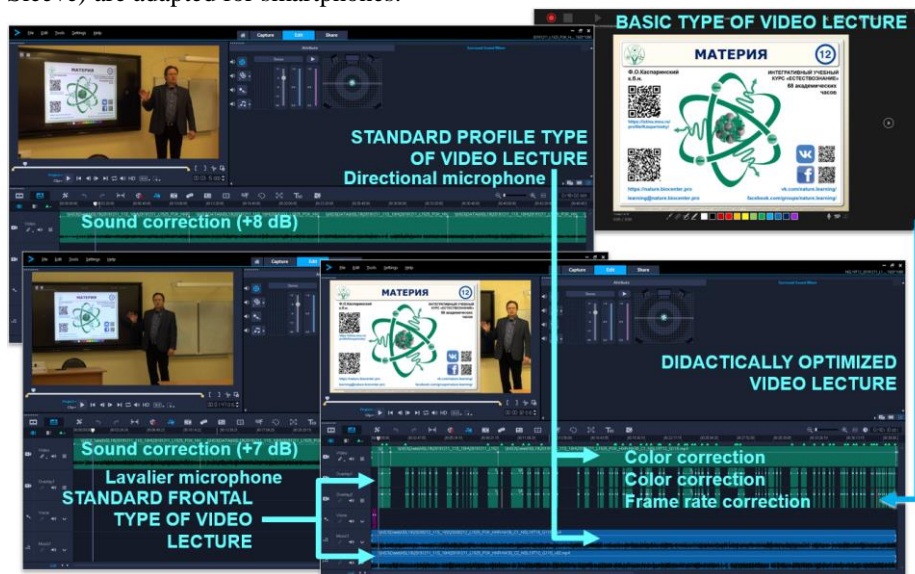

Fig. 10. Workflow diagram for creating didactically optimized video lectures.

In the process of forming video lectures of the "Natural Science" course [11], sound transmission to a SONY HXR-NX30P video camera from a SONY supercardioid electret lavalier microphone via a SONY UWP-D16 premium radio system (frequency range 794–805 MHz) was used as a reference. Microphones (see 3.2 and 3.3) were connected to the camera via an XLR-A1M adapter with phantom power. Both options provided realistic quality of transmission and recording of structurally different audio data, from speech to the ringing of karatals.

3.4 Didactically Optimized Video Lectures

In the absence of video cameras with high-quality optics that ensure the preservation of the detail of visual materials, it is possible to use the technology of editing didactically optimized versions of video lectures. To form the initial editing materials, it is required to create a basic version of a video lecture simultaneously with a video recording of the teacher's actions with one or two video cameras from different angles.

Purposeful didactic adaptation of a video lecture is carried out through contextual editing of near and far frames of a video recording with a basic version of a video lecture and additional media materials (see Fig. 10, example: https://vimeo.com/204236066). Editing should ensure that the attention of students is focused on the process of graphic commenting, emotional reactions, and gestures of the lecturer. To facilitate the synchronization of audiovisual and sound sequences during editing, it is recommended to form a signal that is clearly visible on the audiogram (double clap) before the presentation of the presentation. The main problem when creating didactically optimized versions of video lectures is the laboriousness of their creation (10-fold time consumption, based on the total recording time).
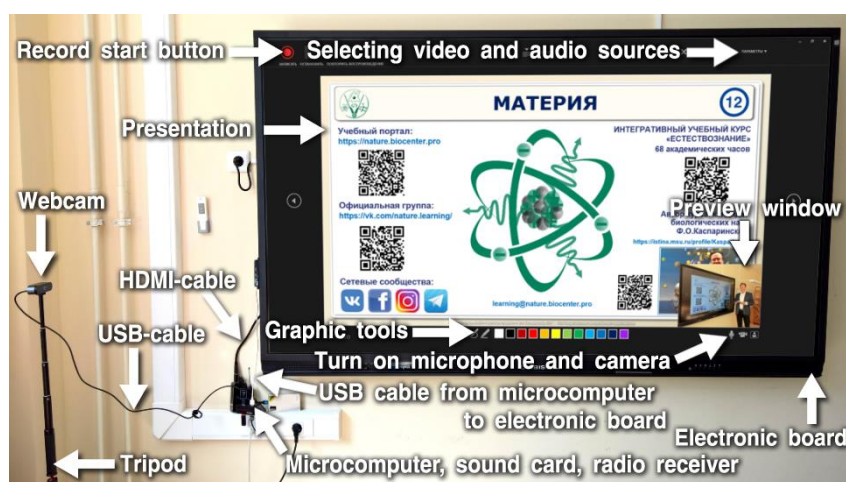

Fig. 11. Organization of video recording of a PowerPoint presentation (Microsoft 365) on a whiteboard and teacher actions (optional).

4   Integrative Video Lectures

Integrative versions of video lectures (combining a video window with a recording of the teacher's actions and a presentation with graphic and voice comments) are created using a USB video camera (webcam) connected to the presentation computer. In full-time teaching, the webcam is positioned on a tripod so that the teacher and the entire electronic board fall into the field of the frame (see Fig. 11). The sound sequence for recording can come both from the webcam and from the radio system receiver from the lavalier microphone (the best option, see 3.3). In the second option, before starting recording, you need to adjust the audio source in the PowerPoint slideshow recording settings (see Fig. 11).

Fig. 12. Screenshot of the frame of the integrative video lecture with graphic comments on the presentation and the teacher.

When you turn on the video camera in the recording mode of the PowerPoint presentation from Microsoft 365, a window with a video frame appears, obscuring the content of the lower right part of the slide (see Figure 11). Video is recorded at 640x480 pixels, but is displayed in a rectangle with an aspect ratio of 360x270 pixels in full-screen viewing mode with a height of 1080 pixels. By pressing the button to turn off the display of the video window, you can get rid of the presence of the video window during the recording of a demo presentation in full-time teaching. During online classes, it is advisable to leave the video window with the teacher's image switched on and broadcast to the students not the PowerPoint presentation window, but the contents of the teacher's computer desktop. In this case, students get the opportunity to see and hear the teacher at the same time as they observe the formation of graphic comments on the slides. The results of video capture of graphic comments and the image of the current teacher are independent of each other and do not change when you turn on or off the mode of viewing the webcam frame.

After exiting the slideshow recording mode, the video window with the recording of the teacher's actions can be moved and scaled. If the presentation design provides for the integration of video recording of the teacher's actions at the stage of exporting an mp4 file from PowerPoint in a specially reserved area of the slide (see 2.1, Fig. 11 and Fig. 12), then it should be borne in mind that by default the video window with the size 360x270 is automatically placed in the lower right part of the slide (Fig. 11) and the audio volume is reduced to 75%. Before exporting a video lecture, the position of the window with the recording of the teacher's actions and the volume of the audio sequence on each slide must be adjusted.

Each slide with integrative video recording can be exported as a separate video sequence. Slides with integrative videos can be combined in any order depending on didactic goals. Taking this into account, it is advisable to maintain an acoustic pause before switching slides.

The main disadvantages of the method of creating integrative video lectures using the PowerPoint Slideshow Recorder functionality are blocking the reverse direction of slide navigation, the impossibility of demonstrating visual materials in addition to the presentation, and the lengthy process of exporting mp4 video.

An alternative method of forming integrative video lectures allows you to get rid of the rigid binding to PowerPoint presentations and in real time combine the video sequence of a webcam in an arbitrary zone with any screen content using a specialized video screen capture program HyperCam, developed by Solveig Multimedia from Tomsk. Using HyperCam, the teacher can show PowerPoint slides in any sequence and switch to other applications, which gives the lecturer unprecedented freedom to use any visual material. After the end of the recording of the lesson, the mp4 file is immediately sent to the HyperCam Media Editor, which allows you to cut off unnecessary ends of the recording and save the integrative video lecture without lengthy transcoding, in a few seconds. To prevent desynchronization of the audio and visual series, it is advisable to trim strictly according to key frames. The program HyperCam favorably differs from analogs in low resource consumption and high quality of compression of audiovisual series. For example, an integrated video lecture with a frame size of 1920x1080 (Full HD), formed in a lesson lasting 45 minutes, is placed in a 500 MB mp4 file. For trouble-free operation, a computer with at least 8 GB of RAM and a solid-state data storage (SSD) is recommended.

Experience shows that in the process of full-time training, the procedure for connecting a set of equipment, loading the operating system, presentations and video capture programs take several minutes, which provides the teacher with the opportunity to maintain academic mobility in accordance with modern requirements and with minimal resource costs organize the prompt creation of your own video lectures during the lesson. Thus, the highest ratio of "didactic quality / resource intensity" is achieved during the formation of integrative versions of video lectures, which are ready for posting on network services within ten seconds after the end of the lesson, during which the video was recorded.

Simultaneous video capture in PowerPoint and HyperCam is not recommended due to the high probability of system failures.

In the case of the high-touch form of distance learning [6], the use of the full-screen PowerPoint demonstration mode is unacceptable, since during the lesson constant visual contact with the students is required simultaneously with the presentation and graphic commentary of the presentation. When forming a video lecture using materials from online classes, another problem arises – the absence or small size of the window displaying the teacher's actions in the video conferencing application. To solve the problems in a comprehensive manner (to provide a high-touch lesson simultaneously with the formation of high-quality video lecture content for subsequent use in high-tech asynchronous mode), the use of a dual set of audiovisual equipment in combination with the PowerPoint window mode and desktop video capture by the HyperCam application allows us to use it. To work, you should use a PowerPoint presentation with a 4:3 slide design, switch it from full screen to windowed mode, scale the window at full height to 60% of the width (1200 pixels) of the FullHD (1920x1080) screen and place

it on the left. The right side of the screen is occupied by the video conferencing application window with the windows of the online lesson participants (see Fig. 13).
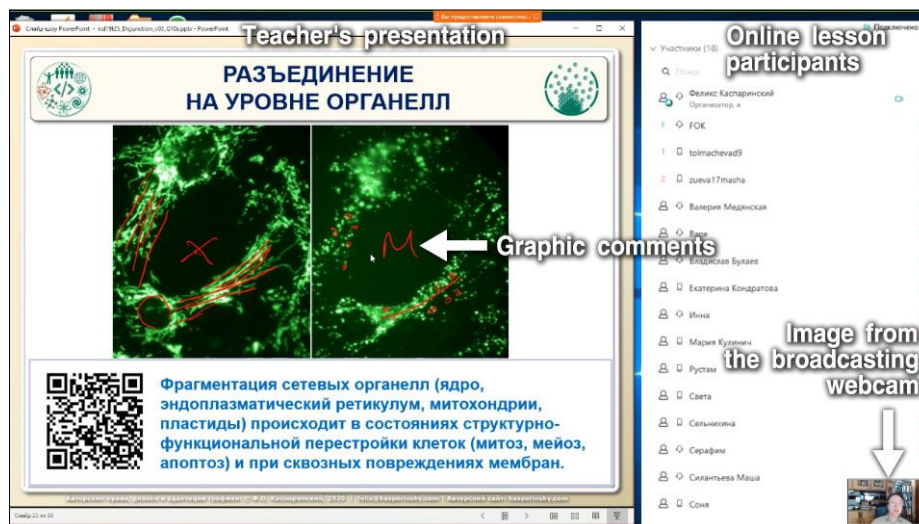

Fig. 13. Screenshot of the teacher's desktop during an online lesson with a PowerPoint presentation.

It should be borne in mind that in the slide recording mode, when the presentation windowed mode is called, duplication occurs in the window while saving the full-screen "mirror" that masks the video conferencing application window. To detect the video conference window and move it over the full screen "mirror" of the presentation, use the keyboard shortcut Alt+Tab. It is advisable to record a lesson using a full-screen video capture of the desktop using a special application HyperCam (version 5 and higher). In this application, you should select a microphone and a video camera that are different from those used in the video conference, and in the preview mode, set the location of the video recording of the teacher's actions over the middle of the video conference window (720x405 or 720x540, depending on the camera settings). The window of video recording of the teacher's actions after activating the capture becomes invisible and in the background, it is combined with the video recording of the desktop demonstration in an mp4 file.

If necessary, in order to comply with the requirements of the Russian Federal Law No. 152 of 27.07.2006 "On personal data", in the video editor, you can set the defocusing of the image on the remaining visible fragments of the video conference window with the faces of the participants in the lesson. When using effects and background soundtrack of a sound card, the sound sequences of video recording and broadcasting are different, therefore, during the final editing of a video lecture, the captured sound sequence should be replaced with a recording from an external recording device that receives audio data from the sound card. As a result of exporting from the video editor, an mp4 file of a didactically full-fledged video lecture, created from media components during a distance lesson, is obtained. The use of recorded videoconferencing systems

as a source of media resources for video lectures turned out to be ineffective due to non-compliance with quality standards.

5 Creation of Integrative Video Lectures in the Process of Online Teaching

The easiest way to form an integrative video lecture in the course of distance learning is to use the broadcasting mode of the teacher's computer desktop when recording a demonstration of a windowed or full-screen PowerPoint presentation, the design of which provides for the insertion of a video window recording the teacher's actions (see Fig. 3). It should be remembered that for a didactically complete online teaching, it is recommended to enable the display of the webcam frame in the PowerPoint presentation settings when the display of the webcam frame is enabled. The display mode of the webcam frame can be changed during the recording of the presentation without any consequences for the quality of the integrative video lecture.

When a PowerPoint presentation window is broadcast online to users' computers in the "Record-Slide Show" mode, only the content area is transmitted.

It should be borne in mind that network broadcasting of video and audio data coming from one device simultaneously with their recording to a local computer causes instability of its work at long times. For simultaneous broadcasting and high-quality recording of an online lesson, two sets of AV equipment should be used. In the absence of a second webcam, it is necessary to disconnect the webcam from broadcasting before activating the "Record slideshow" mode.

The main criteria when choosing video cameras for online broadcasting (webcams) in the process of distance learning are the ability to record video in H.264 format with a size of 1920×1080 and a frequency of 30 frames/sec, autofocus with white balance correction, the presence of an active noise reduction system with two microphones, the presence of a standard 1/4 "tripod mount, the possibility of replacing the USB cable or choosing a suitable length for connecting to a computer with an optimal position for shooting. floodlights), camcorders must support recording with a wide dynamic range of illumination (HDR, High Dynamic Range or more expensive version of WDR, Wide Dynamic Range).

To work with video data when creating integrative video lectures of the Natural Science course [11], we used Logitech BRIO and Logitech C920 webcams (see Fig. 14) with streaming support, connected to one of two involved computers configured [18] to work with audiovisual materials (8 GB of RAM, discrete graphics card, monitor 27"–28" with MVA-matrix). It was found that the direction of the teacher's gaze, forming the graphic commentaries on the slides, appears to be directed directly towards the audience if the main monitor is located above the webcams (see Figure 14). Monitors Iiyama X2783HSU-B3 (upper, main, displays the formation of broadcast content) and X2888HS-B2 (lower, auxiliary, serves to monitor the quality of reception) were located in landscape orientation vertically on the KRON D421FS bracket. It is convenient to quickly switch audiovisual signals between monitors using a 2x2 Navceker ZY-HM22 HDMI matrix switcher.
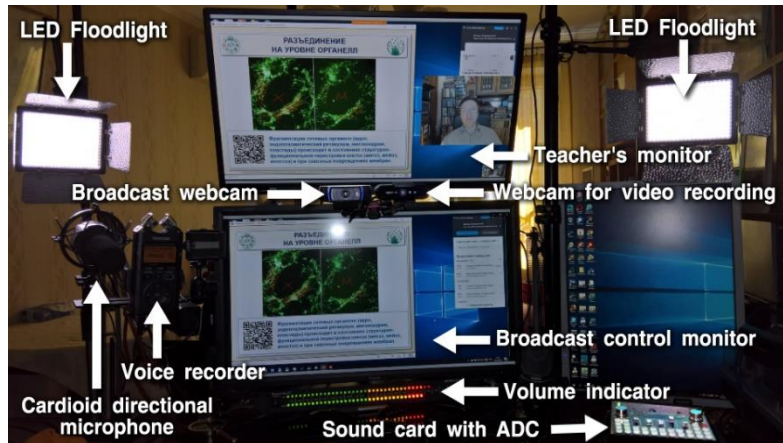
Fig. 14. Equipment of a workplace for online teaching.

In the gap between the monitors at the teacher's eye level, webcams were mounted on the Fasdga SZ-GTFS-I020833 swivel mount with a Ulanzi PT-2 horizontal expansion bar or Neewer 10082556 with a double mount. An alternative way to place the webcams is with the Wellchosen cube mount and a pair of Smallrig 2157 or Jadkinsta WA0196 levers with two ball heads (see Fig. 14). This method allows the webcams to be tilted to provide an overview of the teacher's physical desktop, allowing material objects to be displayed during the learning process. In the multi-camera broadcast mode, using the Logitech Capture program, it is possible to use the online switching of the broadcast source to change the angle or the demonstration object. In case of single-camera broadcasting, it is advisable to control the functions of broadcasting and recording content to avoid conflicting use of one resource. The Logitech C920 webcam was used for video broadcasting, and the Logitech BRIO was used to form a window with a video recording of the teacher's actions (see Fig. 14), combined with video capture of the screen content using the HyperCam program developed by SolveigMultimedia from Tomsk. It was found that the sound scale formed by the microphone of the Logitech BRIO webcam is depleted in the low-frequency region of the spectrum, and therefore it is advisable to use a special microphone to create high-quality video lectures.

External microphones mounted on Neewer NB-35 and NB-39 pantographs with spider shock absorbers were used as alternative methods of audio data input (see Fig. 14). The Shure PG42-USB studio condenser cardioid microphone with built-in ADC transmitted data directly to the computer. The use of a studio microphone was found to be ineffective due to its oversensitivity to ambient noise. To minimize the effect of household noise on sound quality during distance learning, it is advisable to use directional cardioid and supercardioid microphones.

Fig. 15. Audio equipment connection diagram for online teaching.

The Comica CVM-V30 LITE directional supercardioid microphone, directly connected to the audio input of a computer without phantom power, was unsuitable for creating professional-level video lectures due to its low sensitivity. The SONY ECM-XM1 directional cardioid high-sensitivity microphone with low intrinsic noise requires phantom power (48V), which prevents its direct use with a computer. Connecting a SONY ECM-XM1 microphone through a phantom-powered mixer (Muslady D6) connected to the computer's microphone input was ineffective due to the high level of electromagnetic interference, which was reduced by the inclusion of a noise suppressor (Alctron HM-2) in the circuit between the mixer and the computer.

It turned out to be possible to significantly reduce noise and increase the sensitivity of sound recording as a result of connecting a SONY ECM-XM1 microphone to a computer microphone input through a portable preamplifier (Comica AD2, Comica AD3 or Saramonic SR-PAX2), which provides phantom power from an autonomous power source (9 V battery) . The disadvantage of this option is the need for timely replacement of the power supply element. The best choice for a self-powered preamplifier is the Saramonic SR-PAX2, which has an indication of the remaining battery charge.

The most practical option for stationary conditions was to connect the SONY ECM-XM1 microphone to the microphone input of the computer through a preamplifier (Alctron RD501) providing phantom power with 220V power supply. An increase in the quality and volume of a sound recording turned out to be possible in all cases when the audio data was sent not to the microphone input of the computer, but to an external sound card with its own ADC and subsequent data transfer via the USB port (see Fig. 15).

In the process of voice recording with directional microphones, it is not recommended to use speakers to form the sound background due to the inevitable distortion of its amplitude-frequency characteristics. When broadcasting online in the desktop broadcast mode, it is possible to demonstrate audiovisual resources to audiences, but

using them for background design is impractical due to the lack of effective methods of operational control of playback volume, timbre variations, etc.

The choice of a sound card for online teaching is subject-specific. To improve the quality of microphone sound recording (reducing the noise level to -50 dB), it turned out to be enough to use a device of the basic price level ($ 10) with reliable shielding from electromagnetic interference and intelligent noise reduction (Vention CDKHB). The use of specialized for online broadcasting USB sound cards with ADCs in the price range of $ 50 (ALLOYSEED v8; iTECHOR 2880486; K-Song Live F007; MiCWL-M10; SZKOSTON 802575-S8) provides additional reduction of the base noise level (less than -70 dB), control of mixing the sound of two microphones and background music (see Fig. 15). Experiments have shown that the K-Song Live F007 card provides active filtering of background noise with minimal distortion of the voice transmission (KTV+Chat effects). If your work requires additional high-quality sound effects, it is recommended to use sound cards in the price category of $ 100 and above (Tenlamp G3; TKL R1).

When choosing the optimal sound card model, you should pay attention to the ergonomics of adjusting the sound level of microphones, background sound and headphones (used to listen to the sounds of the online audience and background accompaniment), analyze a set of sound effects (applause, laughter, emotional exclamations) and their quality (loudness and accurate performance - smooth start and end), as well as the absence of distortion in the recording mode of the original voice. Background sound from an external audio player, computer or smartphone is fed into the sound card through a dedicated TRS port (see Fig. 15). HiFi-level sound cards allow you to control the volume of the soundtrack in manual or automatic mode (Dodge-effect: reversible decrease in volume when sound from a microphone appears); cut off vocals and change the amplitude-frequency characteristics of the scale.

After connecting the sound card to the computer, it is recommended in the computer Sound control panel (activated by the sequence of commands: "Parameters" / "Sound" / "Related parameters" / "Sound control panel" / "Recording" / "CARD" / "Properties" / "Advanced" / "Default format") switch the card to the recording mode with the bit depth and sampling frequency corresponding to the sound recording parameters during video recording (2 channels, 16 bit, 48000 Hz) to avoid mismatch when editing video lectures.

The monitoring of the sound of the network audience was carried out through headphones (see Fig. 15) connected to the corresponding output of an external sound card, which made it possible to promptly vary the sound volume in hardware as needed. Modern sound cards have one digital (USB-B) and two analog audio line TRRS outputs, specialized for alternative connection to Android and iPhone smartphones, as well as TRS and TRRS outputs for headphones and a headset, respectively. It is advisable to simultaneously output sound via USB-B and one of the line TRRS ports. Through the port dedicated to Android smartphones, you can output an audio signal to the TRS input of external devices, for example, it is advisable to perform additional sound recording with the Tascam DR-40 device in wav format (PCM, stereo, 48KHz).

For real-time monitoring of the optimal volume and selection of microphone equalizers and soundtrack parameters, it is recommended to use visualizers of the general

volume level (Kaisaya Dual 40 Spectrum VU Meter) and the amplitude-frequency spectrum (Kaisaya OLED Music Spectrum Display). In this case, the spectrum visualizer and the voice recorder can be connected to a three-way splitter of acoustic signals (MuxBOXS MB-SH03DA), which connects to the TRS line port or TRRS output for connecting Android smartphones (see Fig. 15). The best option for connecting the volume indicator is through the sound card output for the headset.

Due to the likelihood of acoustic interference during the switching on and operation of auxiliary electrical equipment (power supplies, fluorescent lamps, climatic equipment, etc.), in order to maintain high sound quality, the transmission of analog data was carried out using shielded cables Bochara, GOLLE YLION and KUYIOHIFI.

To control computers, it is advisable to use one set of keyboard and mouse that supports Logitech Flow technology with switching the focus of control when crossing sensitive areas at the edges of screens. Reliability and comfort during long-term work are provided by prefabricated kits "keyboard and mouse" with Logitech Unifying receivers: Logitech K375s and Logitech MX Anywhere 2S (mobile version), as well as Logitech Craft and Logitech MX Master 2S (stationary version). Graphical annotations for the integrative online video lectures of the «Natural Science» course [11] were created during the presentation using the Wacom Intuos A3 tablet.

Experiments with additional lighting (4 Yongnuo YN-300III LED floodlights) in different modes have shown the feasibility of using them with light-scattering filters at the minimum brightness (1–3%). This is enough for the formation of integrative online video lectures with a frame rate of 30 frames per second. The illumination mode provided by two computer screens (27"–28") using the light theme of the application interface is unacceptable for creating integrative video lectures. Under these conditions, the frequency of recording video frames begins to vary from 25 to 12 frames per second, depending on the content of visual materials and the position of the lecturer, which leads to a didactically unacceptable deterioration of the quality of integrative video lectures due to the desynchronization of the audio and video sequences.

Conclusion

In the context of academic mobility, providing for the seamless integration of full-time and distance education, it is advisable to use basic and integrative versions of video lectures. The integrative versions of video lectures, in which the graphic and sound comments of the demonstration of visual materials, are supplemented by video recording of the teacher's actions, inserted into a specially designated place of the basic version of the video lecture, are didactically fully valuable.

The most reliable application for creating integrative video lectures is the Power-Point presentation tool from the Microsoft 365 set with the "Record Slideshow" mode. The best solution for creating integrative video lectures in times of shortage of time and using a variety of applications is to use a specialized video screen capture program HyperCam.

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