Investigating basic channel routing matrix using reaper: designing a surround sound 5.1 instruction model for learning

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ABSTRACT

The production and processing of surround sound are only done in the post-production department for movie and home theaters. In our country, there has been no specific teaching on surround sound systems, especially in channeling. We use matrix routing to define the DAW's channel flow arrangement on the soundtrack. Surround Sound spatial sound processing is indispensable for improving film production in Indonesia. Inspired by Dolby Surround, we independently investigated the matrix channelling on the Reaper DAW to identify the specific settings for getting ready audio mixing conditions with a 5.1 surround system. To understand processes, specific tools are needed to understand large and complex data sets. We went through several experiments and time to understand this, collecting observational data through recording and thinking hard until finally, we poured the process into a model of teaching materials. We offer channel patching on some audio interfaces. The design of teaching materials implemented the findings of this study. Furthermore, the teaching material model can be equipped, used, and adjusted to the conditions of the place of study.

Keywords: Learning instruction model, Routing Matrix, Surround Sound 5.1, University in Indonesia

INTRODUCTION

The advantages of interactive experience technology for society have been the subject of numerous studies. One is using augmented and virtual reality technologies to meet different demands in specific fields. However, VR and AR technology is expected to advance and encroach on other industries in the future (Muñoz-Saavedra et al., 2020). During the Covid-19 epidemic, this immersive technology is extended further (Singh et al., 2020). The educational system is also gradually implementing this technology (Elmqaddem, 2019). Many new media technologies in interaction experiences always strive to appear authentic in their representations (Altavilla, 2020). The element of hearing also needs to be occasionally monitored to in line with technological advancements, in addition to the element of sight. The artificial version of the sound in the form of ambience gets more attention than the natural version (Wierzbicki, 2021). When individuals believe that the media is becoming more and more popular, 3D spatial sound is frequently

designed, reproduced, and used for aural experiences (Cliffe et al., 2021). According to a study, controlling virtual reality environments involves careful consideration, accurate measurement, and comprehension so that users may perceive sensory stimuli effectively (Huisman et al., 2019). This is the foundation for our thinking as we continue to study and expand the use of surround sound systems in science as teaching resources. The technological orientation of surround sound systems explicitly and comprehensively has not advanced significantly in Indonesian education, especially at the university level. To learn more about how to set up a surround sound system, we researched to find a basic manual or instructional module that is simple to comprehend and use. Later, educational institutions or business organisations could use this guide. Of course, research on surround sound systems to recreate spatial sound involves additional study on audio production equipment, recording techniques, virtual and augmented reality applications, and audio mixing techniques to generate immersive perceptions by depicting acoustic surroundings (soundscapes). To assess how much Indonesian universities' curricula have advanced their understanding of surround sound systems' use, particularly for moving image works like film and animation, we performed online observations of the curriculum at numerous Indonesian institutions.

We conducted online observations of the curriculum at several universities in Indonesia to see how far they have deepened their knowledge of the application of surround sound systems, especially for moving image works such as film and animation. There is a course of a study named the Film Study Program at Makassar State University. According to the study program's reputation, it teaches an audio design approach at the same level as filmmaking techniques together with the fundamentals of editing. Both the Padjadjaran and Jember campuses of these universities offer a course of study called "Film and Television study program". However, the two universities' approaches to audio design differ. While Jember University gathers data for cultural material, Padjadjaran University uses content development and film production as broad approaches. Recording Media Arts Study Program, a course offered by ISI Yogyakarta, includes a sound teaching strategy for sound recordists.

The same study program, known as the Film and TV Study Program, is offered at ISI Denpasar and ISI Padang Panjang in contrast to ISI in the Yogyakarta region. Two techniques are used in the study program: basic understanding of movie sound and the editing process in general. The Communication Study Program at the Islamic University of Indonesia employs a generic approach to film production as its method of operation. Lastly, Telkom University offers a Visual Communication Design S1 Study Program that teaches an approach method in the form of Basic Audio Design. The surround sound setting is not visible in those universities. It may be caused by limited facilities and the lack of surround sound system owners among the public. However, it does not rule out the possibility that gradually, vocational education begins to penetrate media technology on sound elements, namely learning about surround sound processing. In this opinion,

the question arises what the initial stage in making a surround sound system is? Although each software provider guides its operation, not all can be understood by the layman. It needs special investigation to find the essence of conditioning the processing of surround sound systems, especially in the software settings and the use of audio interfaces.

In contrast to simply listening to the soundscape, the study's findings demonstrate that the sensory sound of synchronised footsteps helps listeners feel present in a virtual location (a process known as localisation) (Kern & Ellermeier, 2020). The use of sound recording equipment, such as a spherical microphone and 3D audio reproduction (playback), via surround headphones or surround array speakers, is becoming increasingly common in the construction of immersive soundscapes (Hong et al., 2017). When combined with VR visual technologies, spatial sound perception has almost the same effect as true sound (Rajguru et al., 2020). This bolsters the claim that people can orient themselves via spatial sound representations.

Perception can be impacted locally by spatial sound reproduction. The DAW software's sound channel matrix, which is then passed to the loudspeaker system, is needed for the process of spatial sound reproduction. The procedure will go on to the audio mixing stage to demonstrate and gauge the "sense of being in it" or localisation. As a result, further research on cutting-edge technologies is needed to advance the study of spatial sound technology. A lot of research has been done on spatial sound. Due to human resources problems, there hasn't been much study or instruction in spatial sound recording and reproduction in Indonesia. Learning that information is still possible.

METHOD

We conducted this research to find out how to create audio processing conditions for media playback with a surround sound system. To find user guides on surround sound system devices, we carried out two main activities: conducting independent investigations on the functionality and assembling of sound player equipment; and understanding step-by-step usage and feature set in Reaper DAW. Although it is a basic thing, it requires sufficient knowledge and experience to be able to assemble a set of electric sound players and avoid errors that result in damage. Therefore, we try our best so that these basic things do not hinder research by learning from experience. In addition to hardware, proficiency in operating software is also important. So, we did a series of experiments to understand step-by-step setting up a surround sound system on the Reaper.

Software Investigation and Logging

The need for a circular sound system does refer to 5.1 (Elen, 2001). Sound flexibility is experimental and evolving, so every DAW has no fixed configuration reference. As for the DAW, providing a particular surround sound system configuration requires a deep understanding of

surround sound. For that, I did some experiments by investigating the output channeling configuration in the DAW Reaper software. We selected Reaper based on the completeness of standard DAW features, small file size with interface flexibility that user habits can adapt.

We conducted experiments to find the truth in surround sound system configurations. So, to find out, some initial questions are set. The initial question that arises is how to use the ReaSurround effect, to find out its functions in the surround sound system configuration. Continuing to estimate ReaSurround's ability to map voice channels automatically. Then the question of the possibility of routing one track to one output. How ReaSurround can connect with tracks in the software, and about the automation. Then closed with the question of how to activate or create a low-frequency enhancement (LFE). Apart from that, we should also know how the audio interface or sound card configured on the surround sound system in DAW Reaper works. In this case, some questions arise again such as about the specifications of the ideal sound card to work in a surround sound system, or the standard features of a sound card that can be used for a surround sound system. Furthermore, after it is solved, it must also be known how the output on the sound card is mapped in the DAW Reaper. The final question is "Are there any sound system settings already provided in Reaper?"

We did a walkthrough of the exact configuration on some of the tutorial videos on YouTube. We chose a video with a tutorial on the principal configuration, which is a configuration that can be applied to other circumstances and needs of an adaptive surround system. Likewise, when transcribing into writing in the form of step-by-step (Mavers, 2012), we make it as general as possible so that it can be widely understood. The results of the video transcription of the surround sound system channeling become one of the basics in preparing teaching materials in the form of instructional models. To make it easier to understand, we created it in the form of a complete flowchart using Microsoft Visio (Notarianti et al., 2022). Next, we simplify the flowchart so that it can be adapted to various circumstances and conditions and is easier to understand. The teaching components described are channeling, tracking, automating, LFE mapping, and soundcard patching.

RESULTS AND DISCUSSION

The surround sound system of odd-numbered speakers (such as 3, 5, 7, 9, 11, and so on) usually refers to the application of sound to visual displays. An even number of loudspeakers (4, 6, 8, 10, and so on) can be used for sound performances. The development of surround sound systems can be measured by the sound player technology used in mass theaters (Schoeffler et al., 2017). Currently, cinemas in Indonesia use a surround sound system of 5.1 to 7.1.2 (Adi Putra, 2020).

1. Describing The Investigation Process

In the early stages, we explored two surround sound playback methods: the rendering and manual. We imagine that the rendering method is about how the surround sound processing in the DAW is rendered into an encrypted file for later distribution and playback on special equipment or a computer media player (Dressler, 2000). In contrast, the manual method directly plays back the processed surround sound on the DAW without going through the rendering process (Kronlachner, 2014). So, it's necessary to carry several files used in processed projects and always play in the same DAW software and audio interface.

DAW Reaper can route any of its tracks on any of the outputs. However, we will not find an easy configuration to make this happen. The proof is that when we send the channel of a track to one of the physical outputs, the sound does not appear directly on the sound card. And therefore, we must understand the correct channelling. Likewise, with ReaSurround, we cannot automatically operate a surround sound system even though we already use an audio interface that supports surround sound system output. It requires proper understanding and arrangement because although Reaper documents its operating manual in the book, the description is very general and explains more about the basics in Reaper.

Next up, we explore the audio interfaces that can be used for surround sound system needs. We found several options, some high-end soundcards like Steinberg, Presonus, and Scarlett, and some digital audio mixers like Behringer, Soundcraft, and others. We used a digital audio mixer as an experiment. Of course, it requires another setup for a digital audio mixer to receive the surround sound configuration from the DAW via a USB cable. The setting made on the digital mixer is called input patching. Incidentally, a single Input Patch on the Soundcraft Impact can receive two sources simultaneously. We used the 2nd patch source on each channel on the mixer as input to the output of the surround sound system configuration channels on the Reaper. This means the determination of output in the Reaper does not mean it matches the channel fader on the mixer, but it's according to the MADI In number, which is the Input Patch on the mixer.
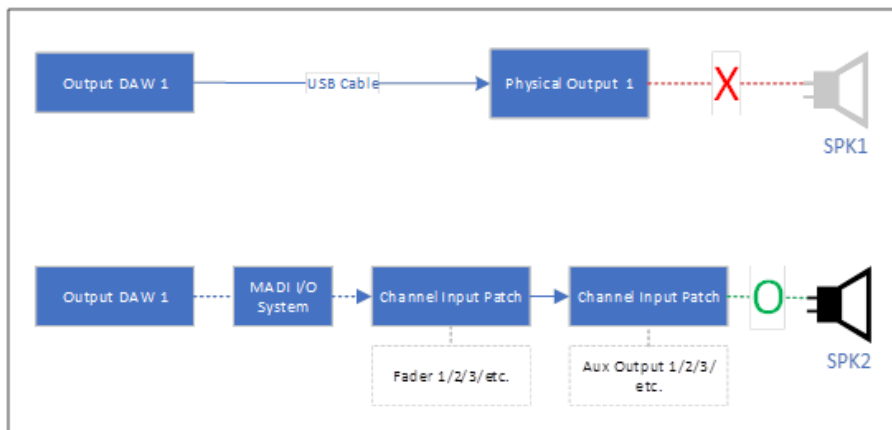

Figure 1. Two comparisons of false (top) and correct (bottom) patching digital audio mixer patching

The selected output number in Reaper depends on what mixer channel MADI In is on. For example, if we choose outputs 1 and 2 on the audio system in Reaper, then MADI 1 is opened on fader channel four, and MADI 2 is opened on fader channel 5. Channel 4 and 5 faders can be forwarded at any Aux, depending on what aux we connect the cable to the loudspeaker. Maybe it will be different if we use a sound card. The output patching process will not be too long, like in a digital mixer. Because it must understand several other setups, namely the Stereo link on the channel fader on the mixer and the choice of pre-fader and post-fader, by using a sound card, the channel patching process is channeled directly into the current outputs.

2. Describing The Track Parenting & Routing Procedures

The first thing to do is project settings setup. The global sample rate must be set at 48kHz. Make sure the Pan law is at 0.0 so that the surround calibration is more focused. The default gain when sending and receiving is set at 0.0dB. To match the fader settings, set the fader range to +12. And last, because we did a hardware output method, we removed the master track view and then saved the project so that the project settings became a template.

The routing key for surround system mixing processing in Reaper is the Track named the channeling master. This track plays an important role in sending the audio source to the parent track for rendering, the parent track for low-frequency monitoring, and the parent track for high-frequency monitoring. This track is where ReaSurround play its role. These settings apply to one sound source, if other sound sources will use the surround sound system, the same settings will be made separately.

The parent track for rendering will be used for rendering needs. This Parent Track consists of six child tracks that will be the source when rendering with the stem method are used. This method allows the software to render with reference to several selected tracks so that the output becomes multichannel. As for monitoring, the division of child tracks for the low-frequency and high-frequency categories is mixed, the separation is in the routing. All child tracks in the low-frequency category will be sent to a track called LFE Total, which aims to accommodate the combined low-frequency of the five surround channels as well as one of the output channels (LFE). Meanwhile, child tracks in the high-frequency category will immediately exit the monitoring hardware, which are routed to the other output channels.

3. Describing Equalising for LFE

In principle, the division of the parent track aims to separate low frequencies from surround sound loudspeakers and channel them to special loudspeakers, the subwoofer. In other words, circular loudspeakers will not produce sound within a certain lower range. The lower range will be sounded by a subwoofer that does not produce mid to high range sounds that are sounded by surround sound loudspeakers. This is termed "the split frequency".

On each track in the high-frequency category, an equalising process is applied by cutting the 80Hz frequency down. This is to avoid frequency collisions when simulated surround sound is performed. While on each track in the low-frequency category, an equalising process is applied by cutting the frequency of 80Hz and above. Thus, the frequency split has been completed.

4. Describing The Matrix Procedure

The main thing that is the basis of this research is the routing matrix. Performing channel routing can be done in any DAW software (Peng & Choi, 2022). The basic principle of the routing process in DAW Reaper software is to open 6 channels on a track to bridge the sound source track with tracks in the monitoring and rendering categories. Furthermore, ReaSurround will work to control the input audio volume of the sound source track at each output in the monitoring tracks. Finally, Tracks rendering works by saving the movement of the ReaSurround area points by using automation envelope writing.

The first step is to create a track that acts as the Master Channel. The track is different from the track master in Reaper. In fact, the actual master track is not used in this configuration. A Master Channel track is a regular track in which sent to the master track are disabled, as are the other tracks in this configuration, there is no delivery to the original master track. Next is opening to six channels to match the 5.1 surround sound channels. This track is also where ReaSurround works, or if you want to use other audio effects such as dynamic fx, filter fx, etc.

Next is to create a track that will be used as a sound source. We also create the track to have six channels because the sound from the track will be mono channeled to all outputs in the monitoring category track. Next is to open the input and output settings on the sound source track, then provide channel submissions. The purpose of this post is to give access to the mastering track to channel sound from the sound source track to the monitoring tracks. The transmission of the sound source track uses the six channels used in the master channel, namely by changing the track channel to six, and opening the send three times with each send having multiple channels, 1-2, 3-4 and, 5-6. The six channels used in both tracks (sound source track and mastering channel track) are intended to provide access to ReaSurround to channel sound from sound source tracks issued across all monitoring tracks.

Audio used for surround sound mixing, must have a single channel principle, except for music (Dressler & Vessa, 2015). In the surround sound mixing process, the audio will be created in stereo or surround. Audio doesn't always have to be channeled across all channels. In surround sound for films, dialogue is usually placed in the center, sound effects are placed in front of the stereo, music is placed in front and side, and ambience is placed in a circle (Geoffrey, 2022). ReaSurround gives users choices about the number of channels and the type of surround to be

used. To simulate the spatial distribution of sound, we select the input channel to be one, then select the 5.1 surround type as the model.
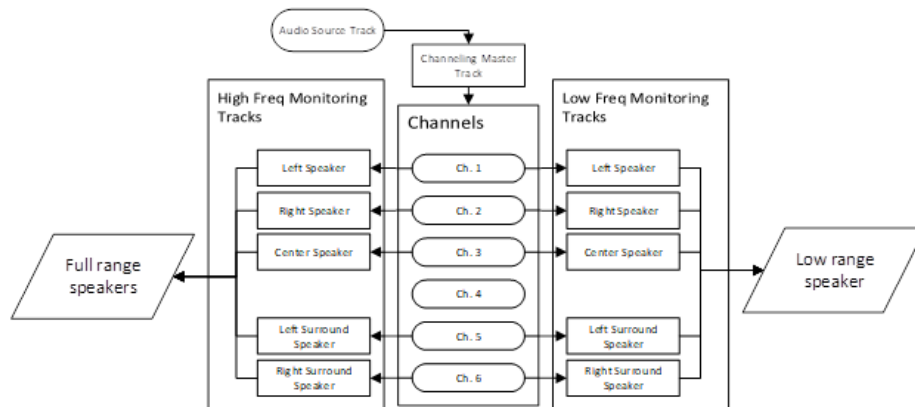
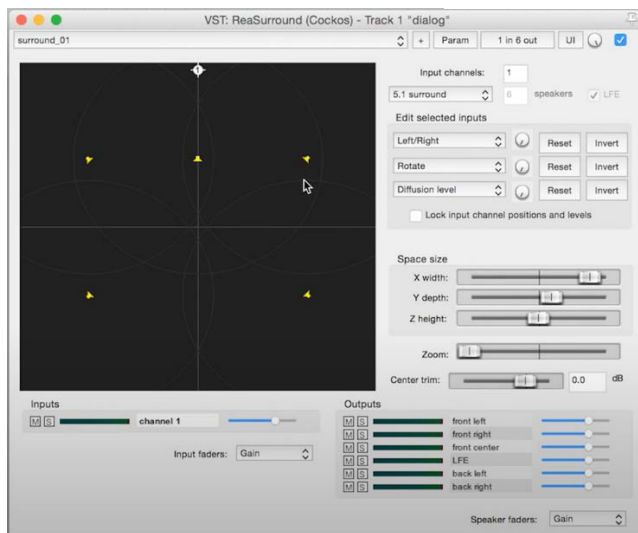

Figure 2. Split frequency flow

Figure 3. ReaSurround display after selecting input channel 1 and output 5.1. (Red square mark)

We can set up a grouping of tracks (parent send) for rendering needs. Like the track monitor category, the track rendering category acts as the end of channeling, receiving audio feed from the master track. However, functionally, this track becomes the Reaper's benchmark for rendering. The result of the rendering process makes the sound separated singly in one file. This means that the sound will sound mono on each speaker, but still follow ReaSurround dynamically. So, each track in the rendering category is made to receive channels from the master mono and sequentially. For example, a track named "Left" will receive channel 1 of the master track mono, a track named "Right" will receive channel 2 of the master track mono, and so on.
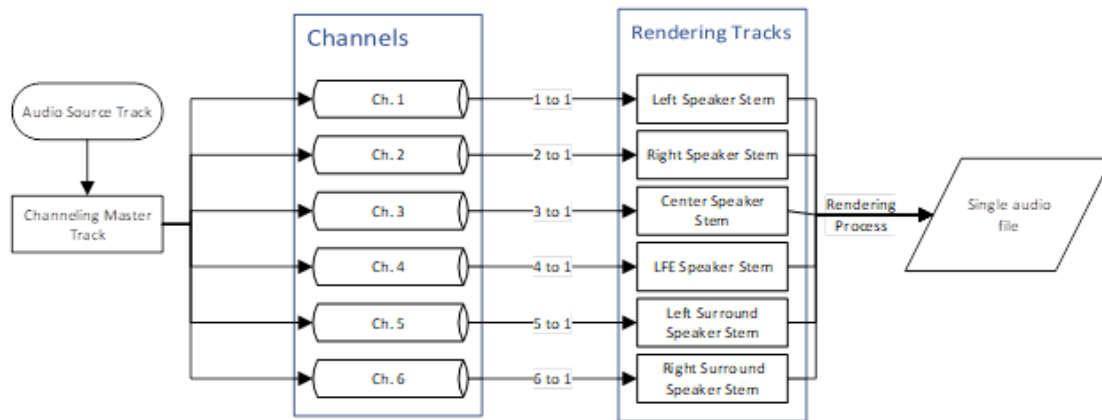
Figure 4. Channel rendering process flow

5. Describing Channel Patching in Audio Interface

There are many audio interfaces with various types and features, ranging from internal to external sound cards. The external sound card is divided into an audio interface device that functions as a signal converter as well, from analog signals to digital signals, and vice versa when used for audio playback. So does for the internal sound card, the difference is that the external sound card can be removed and used portable, while the internal sound card is permanently embedded in the motherboard on the CPU.

Figure 5. Rear view of one external sound card with 8 auxiliary outs (Presonus Audio Box 1818VSL)

With a soundcard such as Figure 5, users can directly determine how much output sound is in the surround sound system configuration. Each output is just opened at the output matrix stage in the DAW software. And so does for the internal sound card (Figure 5), each output is clearly referred to as an output for a surround sound system. The naming is directed at the position of the speakers on the surround sound system, such as front left & right, center, sub/bass, rear right & rear left.
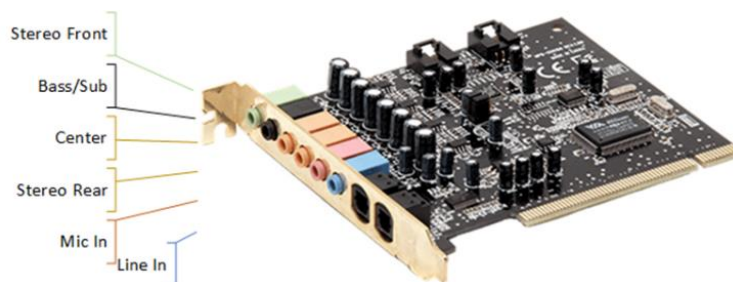

Figure 6. Internal type sound card (source: Wikipedia)

The digital audio mixer allows users not only to function the device as an audio mixer, but also as an audio interface, by connecting it with a USB cable. Several things must be adjusted on the digital audio mixer so that it can function as a sound card used for surround sound monitoring. For example, in the Soundcraft Si Impact digital audio mixer, the sound on each aux output that has been selected on the DAW will not automatically come out of the Soundcraft Si's physical output, but it must be configured first with MADI USB as the mixer interface with the PC as shown in figure 7.
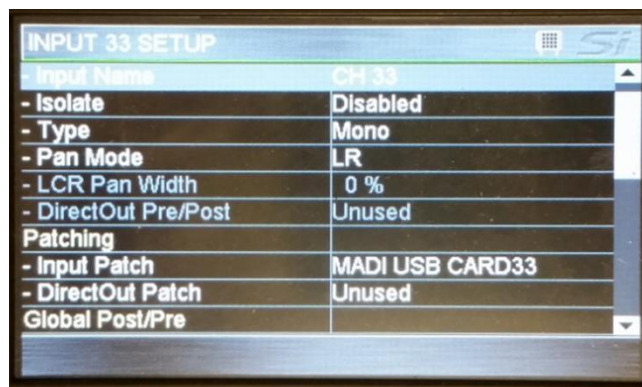

Figure 7. Display of patch input settings on Soundcraft Si series digital mixer with MADI USB for surround sound system

Instruction Model

The process of channeling a circular sound system is related to several things. The basic principle of a surround sound system refers to its function. The first function is how the sound system can represent an aural condition, so the listener feels as if they are there. The second function is to simulate a situation in a film or other types of visuals, such as applying a sound system for cinema. The last part is about its application to virtual reality programming systems. Each function has different processing techniques, sound taking, audio mixing, rendering, and media player. Sound recording can also be divided into two methods: simultaneous spatial input and single input manipulation when mixing. Likewise, in the mixing process, there is the application of processed surround simulations for headphones, the application of processed 3D surround room simulations using special plugins, and the application of actual rooms on high-end devices such as the Dolby Atmos system.

A. Designing Instruction Model

Teachers should know precisely when learning instruction is applied in teaching. In other conditions, usually, an instruction model is used after understanding the impact of its use. It is essential to know that instruction will impact different learners differently. For this reason, a comprehensive experience is needed to provide a broad perspective and build an instructional model (Reigeluth, 2018). Thorough instructions include at least a few points, such as:

- Various conditions and student motivations
- Various conditions of sound studio equipment facilities
- Availability and quality of room acoustics
- Various popular DAW software used
- Various popular audio interfaces used
- Student study curriculum

The instructional model designed in this study refers to instruction in advanced. Audio production basics are prerequisites for learning entry using this instruction. The basic recording process includes sound theory, understanding sound capture equipment, a basic knowledge of recording operations on DAW software, and understanding sound reproduction equipment. Sound learning covers the whole that will be tried to be delivered in one semester, according to the study plan from the results of the initial observations. So, surround sound system learning becomes part of the overall series of learning audio production in general.
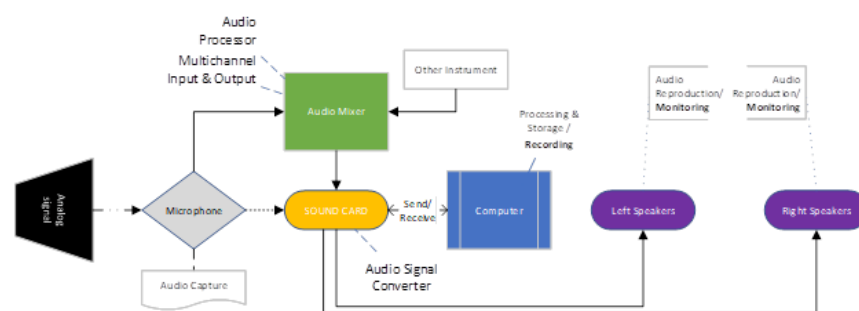

Figure 8. Sound production equipment and flow

The learning participants must pass the recording process well because this instructional model is an advanced stage in audio production, especially the mixing and mastering/rendering processes. Learning objectives are the main thing in designing good instruction, step by step (Gagné et al., 2004). The purpose of developing this instructional model is clearly described in the abstract and introduction sections, which guide preparing audio mixing conditions with a circular sound system. Learning instructions in the form of complete modules cover the entire learning process, from the initial introduction of the material, and the assessment process, to the evaluation of the objective's achievement (Gagné et al., 2004).

Because the ideal teaching material has undergone the experience of implementing instructions and evaluating instructions, this research produces an initial instruction model in the form of a handout, in the form of a description of the primary education in teaching material. Handouts are in the form of writing and pictures that contain an overview of the main concepts. Handouts can make it easier for readers to master and understand the ideas of the material being studied (Hera et al., 2014). Later, the evaluation results from this handout can be developed and refined into a

more complete and mature teaching module, according to the students' conditions and the place where the module is applied.

The content of the handout will begin with the identity of the teaching class such as The Name of the Lesson /Course, Class Name, Level / Semester, and Competency Standards. The second part is about how; Recommendations; for the use of the handout itself. Among them is information that this handout should be intended for those who have gained an understanding of basic sound production before. Notices about the use of DAW Reaper as a software medium in computers can also be submitted here. This includes the use of sound reproduction hardware packages, namely sound cards that support surround sound systems, several audio cables (TRS), some full-range type loudspeakers, and at least one with a sub-range type.

The third part contains learning objectives, the content is about the outcomes that will be obtained by students (James, 2020). The first is the ability to prepare a surround sound system configuration on the DAW Reaper software in the Project Settings menu. The second goal is the outcome of students on their ability to group tracks according to the classification of the sound frequency range. The third goal is that students can understand channel routing on the matrix display correctly and thoroughly. The last purpose is conditional, related to the sound card hardware used (usually if using a digital audio mixer) namely the ability to configure channel patching on the digital audio mixer / sound card.

The fourth part is content, with two main points below it, Achievement Indicators and Key Learning Materials. The instructions contained in the handout must be tested first to find out what instructions are the most ideal in the class (Munna, 2021). Indicators of Achievement in learning are the main points that measure the success of learning (You, 2016). Some of the points suggested in this topic are setting the initial configuration in project settings in DAW Reaper, providing all the tracks needed to map frequency and output divisions and understanding the function of bus channels in DAW Reaper. The Main Learning Material in the handout serves as a presentation of information that students will learn. This section is the basis for students in mastering several points in the achievement indicators. Learning materials include the determination of applied media, namely understanding the designation of the use of surround, whether it is in films, experimental sound, sound art, ambiance manipulation, and so on. The second material is to determine the method of sound recording, between recording a sound source simultaneously with a multichannel microphone or manipulating a sound file with mono or stereo channels into a surround format. The third material is about the reproduction method, which is between playing through the medium of a sound player that supports a surround sound system, such as KM Player, and so on; or playing/presenting directly from the DAW. Then the type of DAW should also be considered because it will relate to the configuration in the software (for this context it is recommended to use a Reaper DAW). After the DAW is determined, the next step is

about how to do the initial configuration, such as Pan Law, Fader Gain, a configuration of the software interface display, and so on. The next step is per the main setting process of the surround sound system in the software, namely providing tracks for channel separation, conducting matrix routing to ensure that the channel is properly traced, using the channel bus, separating frequencies by the track categorisation method, understanding the settings on the sound card used, and the last is to experiment to play the sound to ensure that the sound is crossed correctly.

The last part is an evaluation to determine students' understanding ofhe teaching material (JH & Baderiah, 2020). This evaluation can be packaged in the form that best suits the conditions of the class. Two ways can be done in evaluation can be both tested or personal tested, evaluation in conceptual form and perceptual form (Lee & Labroo, 2004). The purpose of the conceptual evaluation is to sharpen the practical skills of learning, while the purpose of the conceptual evaluation is to deepen their understanding. Some points that can be developed in conceptual evaluation are asking students to mention the steps for preparing the surround sound system configuration according to their abilities, Project Settings, Channel bus matrix, and surround sound manipulation with automation features. Meanwhile, the points in the perceptual evaluation are to ask students to re-infer the different types of recording and some types of sound reproduction techniques, the functions of the bus channel matrix, and mention their interest in the configuration of the surround sound system. This handout then ends with a library reference attachment.

CONCLUSION

Search and investigation to find the standards circuit to condition the readiness of surround sound system processing was the main study. This research includes proficiency in processing sound digitally in software on a computer. The results of this study are in the scope of advanced sound processing after mastering the basics of recording and audio editing processes to the stage of readiness for processing surround sound systems. This arrangement is then processed more simply so that it can be understood by users or students who already have pre-competencies in audio production. The results of this study have an impact on awareness of the discourse of audio processing competence, the development of creativity, sharpening teaching in the field of digital audio processing, and then becoming a reference for breakthroughs in art presentation. The flow chart is described as descriptive instruction, so it can be a teaching material for self-instruction. Before going any further into designing teaching modules, we chose to present this series in terms of handouts. Once tested and evaluated, the handout can be turned into a teaching module. This teaching material complements the curriculum in the field of multimedia production in every university in Indonesia. These teaching materials must then be tested under every condition in every college that needs them.

This research can continue other research that is still within the scope of processing surround sound systems, namely regarding sound localisation. It is a study that is still rarely discussed in the vocational world, especially in applied sound processing. Sound localisation intersects with research on calibrating the intensity of loudness of sound, processing frequency equalisation based on perception, panner stereo calibration experiments for audio location information, to exploration for manipulation of the atm system. The output is the ability of sound in directing the perception of the listener's imagination which can be useful for performance works, multimedia applications, to the field of medicine as a therapeutic medium.

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