INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES
HRMARS MANAGEMENT ACADEMIC RESEARCH SOCIETY EXPLORING INTELLECTUAL CAPITAL
www.hrmars.com
ISSN: 2222-6990

Audio Sampling Method in the Development of an Electronic Gamelan: Kromong GaMelLED

Zaharul Lailiddin Bin Saidon, Nazimin Bin Nazeri

To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v12-i12/15542 DOI:10.6007/IJARBSS/v12-i12/15542

Received: *14* October *2022,* ***Revised:*** *17* November *2022,* ***Accepted:*** *27* November *2022*

Published Online: *19* December 2022

In-Text Citation: (Saidon & Nazeri, 2022)

To Cite this Article: Saidon, Z. L. Bin, & Nazeri, N. Bin. (2022). Audio Sampling Method in the Development of an Electronic Gamelan: Kromong GaMelLED. *International Journal of Academic Research in Business and Social Sciences*, *12*(12), 1132 – 1145.

Vol. 12, No. 12, 2022, Pg. 1132 – 1145

http://hrmars.com/index.php/pages/detail/IJARBSS | **JOURNAL HOMEPAGE**

Full Terms & Conditions of access and use can be found at
http://hrmars.com/index.php/pages/detail/publication-ethics

INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES
HRMARS MANAGEMENT ACADEMIC RESEARCH SOCIETY
EXPLORING INTELLECTUAL CAPITAL
www.hrmars.com
ISSN: 2222-6990

Audio Sampling Method in the Development of an Electronic Gamelan: Kromong GaMelLED

Zaharul Lailiddin Bin Saidon, Nazimin Bin Nazeri
Sultan Idris Education University, Malaysia

Abstract
The development of digital musical instruments software like the digital gamelan has contributed significantly in terms of providing accessibility to learning musical instruments, especially among school children. However, there were limitations in the existing digital gamelan applications found in the market. This article is based on a research project undertaken with the aim of developing an electronic musical instrument called GaMelLED Kromong which resembles one of the musical instruments found in the gamelan ensemble. The focus of this article is to discuss the audio sampling process as one of the phases undertaken in the study. Audio samples play an important role in the development of GaMelLED Kromong because they had an impact on the application of the instrument along with the creative work performed. This study was undertaken through a practice-led research approach which includes methods such as (i) media analysis, (ii) trial and error, (iii) critical peer, and (iv) reflective journal. The findings of this study show that audio sampling through the reflective method could reduce the quality of Kromong audio samples in terms of noise frequency reduction of around 125hz-8khz, more accurate adjustment quality without digital editing which produces a much clearer tone. Apart from the creation of an electronic Kromong that is smaller, lighter, cheaper, and more portable, the outcome of this study has contributed to a new method for an audio sampling of Kromong, especially with regards to the technical elements of recording using minimal equipment that is by simply manipulating the position of the Kromong during the recording process.
Keywords: Recording Techniques, Audio Sampling, Malay Gamelan, Kromong, Practice-Led Research.

Introduction

Music technology is increasingly getting more advance and has contributed to various aspects of life including innovation in the development of digital and electronic musical instruments. Similarly, there has been much progress and innovations in the development of music software to be used with communication devices such as tabs and smartphones. The development of digital musical instruments software has contributed significantly in terms of providing accessibility to learning musical instruments. As for gamelan, the reasons behind the development of digital gamelan applications were factors such as the relatively expensive gamelan set and the rather large size of most of the gamelan instruments (Engkur et al., 2019) as well as the lack of portability (Shafik et al., 2014). Nonetheless, there are limitations in the

existing digital gamelan applications found in the market. The main challenge encountered was that musicians were unable to apply the conventional techniques of playing the traditional gamelan instruments when using smartphone applications or on the musical instrument digital interface (MIDI) keyboards. Tjahyanto (2011), emphasized that a gamelan musical ensemble is a set of traditional percussion musical instruments that are played by using mallets and hitting the body of the instruments as the word 'gamel' means to beat or hit (Salinah, 2017).

This article is based on a research project undertaken with the aim of developing an electronic musical instrument resembling one of the musical instruments in the gamelan ensemble that is the Kromong. The main consideration of the project was to enable conventional percussion techniques similar to the traditional playing technique of the gamelan to be applied to electronic Kromong. Specifically, the research project aimed at developing an electronic clatter named as GaMelLED resembling one of the Malay gamelan musical instruments known as the Kromong or Bonang (Sheppard, 1967). The development of GaMelLED Kromong was carried out in several phases including the audio sampling phase. This article focuses on the analysis and sampling methods of audio speakers in the development of the electronic Kromong.

Background of the Study

The motivation and inspiration to embark on this project started from the curiosity to study the practice of the audio sampling method specifically for the Kromong recording technique. Although there are various samples of Kromong audio in a syntax such as the keyboard, the uniqueness of Kromong audio sampling is seen as a process of understanding the unique overtone frequency (Hamdan et al., 2019) and has other methods of recording which could be further explored. For this purpose, an audio recording process was carried out using the Kromong of the existing gamelan set at the Faculty of Music & Performing Arts, Sultan Idris Education University, Tanjong Malim, Malaysia to obtain audio samples that can be used for the electronic GaMelLED Kromong that was developed in the project.

Review of the literature shows that several studies were conducted related to gamelan and digital audio (Craig & Parry, 2019). Among others, there were studies that focus on the unique harmonic synthesis structure of the gamelan ensemble by (Lydia, 1996). In addition, there were studies that focus on notating natural algorithms for different types of gamelan music like the one conducted by Matthews (2018). There were also computer software studies for the use of composition in applying gamelan music theory processes to musical notation carried out by (Khafiizh & Mustafa, 2016; Gerd, 2008). According to Craig and Parry (2019), there are various potentials to develop concepts for gamelan music theory down to audio cues, more than just number notation that can be used in audio production and audio design. In addition, an audio recording of Kromong is also a study that investigates the science of sound (Anggraeni et al., 2019) in order to analyze the spectrum of Kromong with overtone frequencies (Hamdan et al., 2019, 2020).

Methodology

This study has employed the practice-led research (PLR) approach. Data were gathered through (i) media analysis, (ii) trial and error, (iii) critical peer, and (iv) reflective journal.

Media Analysis

A preliminary study was initiated using the media analysis method. As suggested by Denecke (2009); Knoblauch et al (2006); Leblanc (2018), video media are used by art activists and researchers as an initial reference to their research projects in order to gather relevant information and latest updates on the topics of study. Hence, for the purpose of this study, media analysis was conducted on previous research related to gamelan audio recordings, especially on Bonang or Kromong which includes a study conducted by Hamdan et al (2019, 2020). In addition, video media observations on YouTube channels were conducted to examine the recording techniques used in the Kromong audio sampling process which include videos by (Meizan, 2018; Chon, 2018). The focus of the media analysis was to identify the settings and equipment for the recording process as well as the methods of analysis used. Specifically, the information gathered includes aspects such as interface device type, microphone type, and microphone distance (Hamdan et al., 2019, 2020; Meizan, 2018; Chon 2018). Media analysis using music software and Digital Audio Workstation (DAW) was performed after the Kromong sounds were recorded. Analysis of sound quality was performed using a spectrogram, a multimeter, and an audio analyzer.

Trial-and-Error

In this study, the trial-and-error method was applied to try out several procedures that were likely contribute to achieving the objective of the study. According to Callander (2011), the researcher will learn by observing previous choices and the outcomes of the trial-and-error process. This method is normally used in studies to assess aspects of knowledge that have undergone a process of repetition (Miklaszewski, 1989; Young, 2009). According to Edwards (2004), the trial-and-error method is one of the well-established techniques used by beginners. In the context of this study, the trial-and-error method was used in determining the distance between the microphone and the speaker. In this project, the trial-and-error method was used when the position of the Kromong was changed several times in order to obtain various different audio samples. In addition, the trial-and-error method was also used to explore new methods which were subsequently analyzed in order to compare the results from the two recording methods used.

Critical Friend

The involvement of a critical partner in the process of electronic Kromong development was to obtain views or criticisms from a different lens. According to Stenhouse (1975), a critical partner is seen as a partner who is able to advise and collaborate in the research process. Critical peer involvement is seen as an agent that can contribute especially in the self-study methodology (Garbett & Ovens, 2018). The critical peer method is used to obtain views from different lenses as well as to examine the practices of a researcher and to provide feedback to improve the results of the study (Andreu et al., 2003). In this study, during the audio sampling phase, our critical friend was asked to listen to several audio samples in order to gain insights for improvement which were notated in our reflective journal entries.

Reflective Journal

At the outset, we took into account the statement by Boud et al (2001) who stated that although the researcher will undergo the experience of conducting the research, it is incomplete without any good reflections. Boud further asserted that the researchers do not learn from experience; instead, the researcher learns from the reflection of the experience.

We also agree with Korthagen's definition of reflection as a mental process of trying to organize or rearrange experiences, problems, and knowledge. Therefore, as suggested by Schon (1987), the reflective journal we kept was a significant source of data for us to look into our investigation more holistically using our own conscience. For the purpose of the Kromong audio sampling process, the reflective journal was useful during and after the cycle of actions and reflections undertaken to obtain audio samples without any digital adjustment to the timbre or harmonic frequencies of the Kromong sound.

Audio Sampling

Basically, there were two recording methods that were employed for the purpose of the audio sampling process in this study. The first method used was the audio recording of the Kromong as conducted by (Hamdan et al., 2019, 2020). The second method was discovered as a result of successful attempts by the researchers through the process of trial and error and reflection. The Kromong available at Sultan Idris Education University was used for the recording. The recording was carried out in a gamelan studio with sound absorption facilities to reduce unwanted noise during the recording process as suggested by (Lusi & Yudhiakto, 2017). Standard recording tools which include balanced XLR wires, microphones, audio interfaces, and computers were used in both recording methods without changing any equipment in order to ensure the results will show the differences in recording methods rather than the equipment as proposed by (Hamdan et al., 2019). The ESI QuataFire 610 interface device, the Shure SM57 dynamic-type microphone, and also the Samson Overhead condenser microphone were used as tools in the sampling process.

Following the audio sampling process using both the above methods, the audio product was analyzed and the developmental process was recorded in the reflective journals as suggested by Smith & Dean (2009) for the purpose of presenting our views, thoughts, and directions that have occurred when we reflect as well as to document the creative practices. In addition, the recorded audio samples were re-listened using a loudspeaker to a critical partner (Stenhouse, 1975) in order to obtain a different view other than that of the researcher. By employing the PLR approach (Smith and Dean, 2009), this study has contributed to the theorizing practice of audio sampling. Starting from the curiosity of a practice (Hill & Lyold, 2015) to a deeper understanding of the practice of audio sampling methods that can be used alongside the development of the electronic Kromong. In addition, the PLR approach has provided opportunities for researchers to be more open in terms of creativity in developing unique processes for creative works and research (Gray, 1996; Smith & Dean, 2009).

Audio sampling is a process of converting continuous analog signals into a sequence of digital numbers (Mutagi, 2004). Audio sampling is also a process of recording the sound source at one part at a time where each recorded part is then inserted into a sampler in the music software or DAW. The advantage of running the sampling process is to save time when playing back the audio that has been sampled, is easy to store, and is in a computer-readable format (McGuire & Pritts, 2007). Usually, the audio frequency for sampling is in multiples of 44.1kHz or 48kHz (Hummel, 2016). The value corresponding to the amplitude is represented by the digital system and is shown as a 16bit or 24bit digital value.

In this study, we used a standard recording method that is 16bit rate and 44100hz frequency per sample. The buffer size was set at 512 samples to reduce the element of delay during recording. Once the settings for the software was run, the microphone was placed in the first position facing the Kromong. Each Kromong was tapped one by one with a distance of 10cm between each tone to get the wavelength and to facilitate editing. Each Kromong was tapped using the same level of force to obtain a balanced velocity.

The position of the microphone was changed when the recorded audio sample did not meet the requirements of the researchers. Although the sound was evaluated subjectively (Fastl, 2013), there was a need for the recorded audio samples to have resonance and long echo in order to obtain an aesthetic sound that is almost the same as the Kromong from the acoustic aspect. The concept of psychoacoustics is like a bridge between the world of physical measurement and the world of subjective evaluation (Fastl, 2013). According to Fastl (2013), among the examples that explain the concept of psychoacoustics are sounds that sound loud, booming, squeaky, fluctuating, and others. Examples of physical measurements of the sound are level, spectrum, time function, and so on.

Figure 1: The microphone position of the first method.

Figure 1 above shows the first recording method used. The position of the microphone was placed on the Kromong with an angle of almost 90 degrees and has a distance of 20cm between the microphone and the Kromong. This method has also been used in several past studies (Hamdan et al., 2019, 2020; Meizan, 2018; Chon, 2018). Based on the researchers' experience and observation who are activist in Malay Gamelan music, this position is usually used to get the overall sound from the Kromong during the performances and recordings. However, through observation made, this method can still be further explored. This idea arised when the researcher was positioning one of the Kromongs. It was discovered that if reversing the Kromong of the same tone but in a different barrel and then placing under the Kromong that is to be sampled will consequently refract the wave from one Kromong tone to the tone below it. This is shown in figure 2.

Figure 2: Second recording method.

Referring to Figure 2 above, it was found that the echo produced was sustained longer and the sound quality produced was much clearer. These changes also produced different frequencies than the first recording method. The resulting frequency differences were analyzed using Blue Cat's FreqAnalyst Pro Virtual Studio Technology (VST). The analysis was performed to see the differences in pressure variations that could be assessed using wave graphs (Bryd & Crawford, 2002). Bryd and Crawford (2002) also stated that there are three ways to present sound and music, namely using digital waves or audio, musical notation and also time-stamped event forms. In this study, we used digital waves or audio as the sound representation and were then arranged in tables.

There are several steps required for the audio sampling process and it is the first step in converting analog data to a sequence of digital numbers (Mutagi, 2004). In this study, audio sampling was used in two processes which is during the Kromong audio sampling process and the second was during the application of GaMelLED Kromong with audio. The occurrence of audio data conversion process occurred during the sampling process. The frequency received by the microphone was sent to the audio interface, then the analog data conversion took place and was converted to a sequence of digital numbers. This digital audio sequence was also visualized in DAW software using waveforms (Bryd & Crawford, 2002) that allow us to analyze the input before editing and saving.

Findings

As a result of the exploration and successful attempts using the first and second method, it was found that these two recording methods produced different audio samples but still in the same tone. There were some differences in the result despite using the same equipment in audio sampling which was microphone type, recording space, and interface device. Therefore, the researchers performed some audio analysis to select the best method in Kromong audio sampling to be used by GaMelLED Kromong in the performance of creative works.

Table 1
Analysis of Kromong audio sampling.

		First Method		Second Method	
Kromong tone	Tone	Frequency	Amplitude	Frequency	Amplitude
1	Bb4	472hz 21cents	-29db	478hz 44cents	-56db
2	C4	268hz 43cents	-34db	272hz 65cents	-28db
3	D4	297hz 21cents	-33db	297hz 21cents	-24db
5	F4	351hz 10cents	-35db	356hz 32cents	-30db
6	G4	389hz 88cents	-37db	394hz 10cents	-25db
i	Bb5	957hz 45cents	-17db	957hz 45cents	-14db
2’	C5	537hz 44cents	-18db	544hz 66cents	-16db
3’	D5	595hz 22cents	-23db	580hz 77cents	-19db
5’	F5	712hz 33cents	-24db	712hz 33cents	-17db
6’	G5	799hz 33cents	-29db	810hz 56cents	-28db

Based on the analysis of the audio samples using the first method, there were frequencies ranging from 62hz to 1600hz. The higher frequency is at 500hz, while for the subjective hearing of the researchers can state that this method produces an indistinct tone. The audio analysis was recorded as in table 1. For the second recording method, the study found that the frequency of the Kromong started at 125hz up to 8000hz. This recording method reduces unwanted frequencies as well as produces longer echoes than the first recording. It was further found that this method produced a more accurate key tuning than the first method.

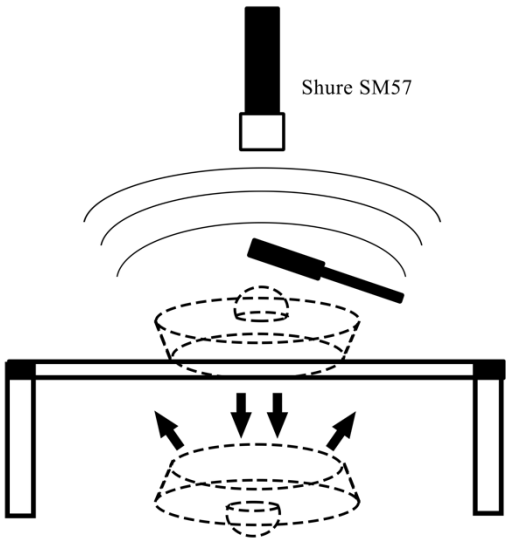

Figure 3: Reflection Method of Kromong Audio Sampling.

The results of the recording process found that the audio sampling method of Kromong that can be used for the application of electronic Kromong is the second recording method as in figure 3 above which is named as Reflection Method. This Reflection method uses two Kromong, the beat of the Kromong above refracts waves into Kromong at the bottom (same key but different tuning) then produces a longer resonance and clearer key tuning adjustment.

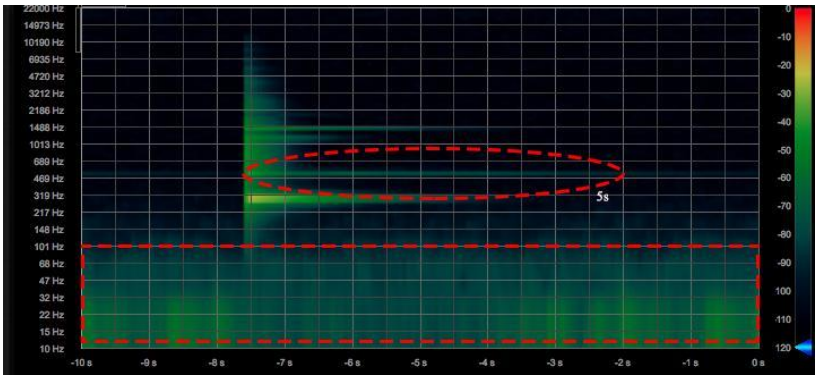

Figure 4: Analysis of Kromong Tone Sample C Using the First Method.

Referring to figure 4 above, the recoded audio samples using the first method have an unwanted noise frequency around 10hz - 101hz. While the analysis shows that the frequency of this audio sample gradually disappears in the time period of about 5 seconds.

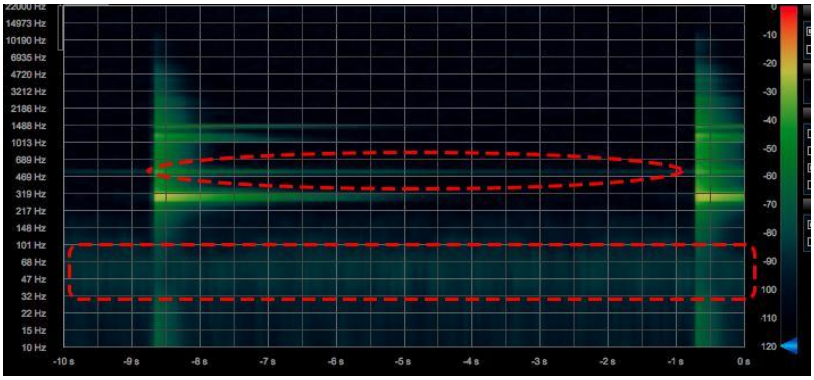

Figure 5: Analysis of C Kromong Tone Sample Using Reflection Method. (Source: Nazimin)

Looking at the differences of sample analysis using the Reflection Method as in figure 5 above, the recorded sample only has a noise frequency around 32hz - 101hz and the amplitude of that frequency was not too high. While the frequency of this sample has a fading tolerance of about 8 seconds. Once the audio analysis process was completed, the audio samples of the Reflective Method were selected as audio samples that could be presented in the performance of the creative work. The final process for this audio sampling was to classify each sample according to the tone and barrel, then proceed to store it into a folder.

Framework of Kromong Audio Sampling Practice

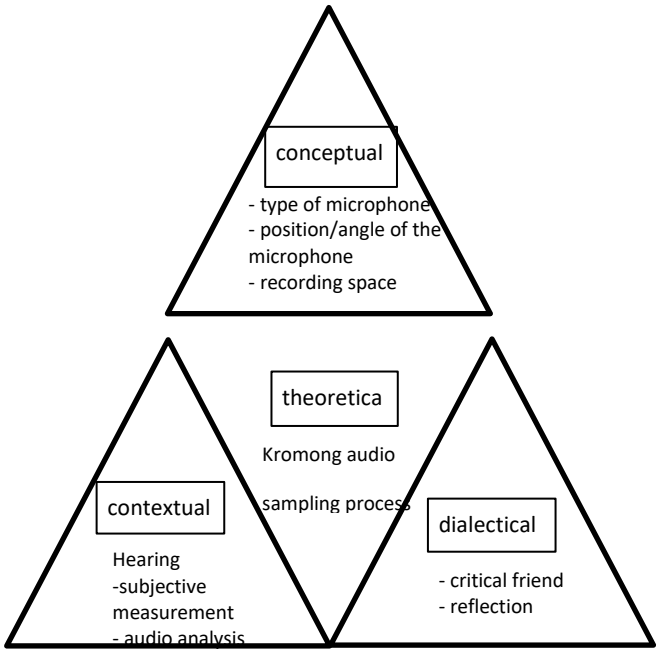

Figure 6: Framework of audio sampling practice

The figure above is a practical framework for the Kromong audio sampling process that was carried out. It is one of the important findings in studies that use PLR methods (Smith & Dean, 2009). Based on the framework, it can be stated that the conceptual aspects that contribute to the Kromong audio sampling process are the type of microphone used, the microphone tuning angle, and also the space for recording. While the contextual aspect of audio is evaluated based on the spatial hearing of the researcher as well as the influence of critical peers. The contextual aspect of this Kromong audio sampling process uses two

assessments which are subjective measurements such as sound that is too sharp, less resonant, and too thin. Apart from the subjective measurements, audio analysis was performed in detail using audio and visual software such as spectrograms to analyze each aspect of the audio such as amplitude, adjustable accuracy, and duration for each audio sample. The dialectical aspect used in the audio sampling of this Kromong is a critical partner and a reflection of the researcher. The recorded audio will be listened to by a critical partner to get a different opinion. The reflection will link all the findings and then produce a theory for the whole process (Smith & Dean, 2009).

Conclusion

The main aim of this study was to analyze the differences in the recording methods to obtain audio samples of Kromong that can be used with GaMelLED Kromong which was developed in the project. Using the Practice-led research approach, several methods including trial and error, the use of critical partners, media analysis, and even reflective journal entries were as alternative methods in exploring the existing Kromong audio recording methods. The findings of this study have contributed in terms of suggesting a practice framework for the Kromong audio sampling process adapted from the Framework of Practices developed by (Smith and Dean, 2009).

Based on the framework of the practice, there are three practices that make up the theoretical development namely dialectical, conceptual, and contextual. Using such a framework of practice, the researchers were able to develop a theoretical process for each of the requirements of the research questions. For the focus of this article, the practices used in this research method contain digital, technical, and subjective elements. As an example of the conceptual practice, there were several aspects that needed to be emphasized in order to record a Kromong audio sample, which includes the position of the microphone, the type of microphone, and the recording space. While for contextual practice, it covers the subjective characteristics of the listener's sound as well as audio analysis techniques using appropriate digital or analog tools. As for the dialectical practice, an example of an activity for this practice is by using the method of trying to succeed during the study or involving a community such as a critical partner to get views. The results of these three aspects of the practice will form a theory that can be an overview of the research process that has been conducted (Smith & Dean, 2009).

From the technical aspect of the recording, a new method was discovered based on the process that has gone through the research phase and testing based on the Kromong standard recording method used by (Hamdan et al., 2019, 2020; Meizan, 2018; Chon, 2018). The Kromong audio sampling method called the Reflection Method is the result of the researchers' exploration and success in obtaining a clearer Kromong audio sample as well as having an echo without digital editing. Through the Reflection Method, the audio sampling process has produced audio samples of Kromong in the frequency range 125hz - 8khz. No editing was required in maintaining the harmonic frequencies that result indirectly from the Kromong musical instrument. The resulting tone also sounds much clearer without the help of any editing. A complete audio sample of Kromong was produced for application by the electronic Kromong in composition and performance. In short, we would strongly suggest the audio sampling method that we conducted and analyzed to record audio samples of Kromong using minimal equipment by simply manipulating the position of the recorded Kromong.

Corresponding Author
Zaharul Lailiddin Saidon

Reference

Andreu, R., Canos, L., Juana, S. D., Manresa, E., Rienda, L. & Tari, J. J. (2003). Critical friends: a tool for quality improvement in universities. *The Emerald Research*. *11*(1), 31-36. http://doi.org/10.1108/09684880310462065

Anggraeni, D. P., Sukarmin & Nurosyid, F. (2019). Teaching sound waves using gamelan and smartphones. *International Conference on Physics and Its Application*. *1153,* 1-7. http://doi.org/10.1088/1742-6596/1153/1/012123

Boud, D., Keogh, R., & Walker, D. (1985). *Reflection: turning experience into learning*. Routledge Falmer, Taylor & Francis Group

Bryd, D., & Crawford, T. (2002). Problems of music information retrieval in the real world. *Information Processing & Management*. *38*(2), 249-272. https://doi.org/10.1016/s0306-4573(01)00033-4

Burkner, H. J., & Lange, B. (2017). Sonic capital and independent urban music production: Analysing value creation and 'trial and error' in the digital age. *City, Culture and Society*. *4*(2), 29-31. http://dx.doi.org/10.1016/j.ccs.2017.04.002

Candy, L. (2006). *Practice based research: a guide*. Creative & Cognition Studios. http://www.creativityandcognition.com/wp-content/uploads/2011/04/PBR-Guide-1.1-2006.pdf

Callander, S. (2011). Searching and learning by trial and error. *American Economic Review 101*. 2277-2308. http://www.aeaweb.org/articles.php?doi=10.1257/aer.101.6.2277

Chon. (2018). *Recording on bonang gamelan* [Video]. YouTube. https://www.youtube.com/watch?v=lUwEpsUhfhQ

Craig, L. M., & Parry, R. M. (2019). A real-time audio effect plug-in inspired by the processes of traditional indonesian gamelan music. *International Conference on Digital Audio Effects. 22*(1), 1-8. https://www.dafx.de/paper-archive/2019/DAFx2019_paper_52.pdf

Denecke, K., & Nejdl, W. (2009). How valuable is medical social media data? Content analysis of the medical web. *Information Sciences*. *179*(12), 1870-1880. https://doi.org/10.1016/j.ins.2009.01.025

Dewey, J. (1933). *How we think: a restatement of the reflection of reflective thinking to the educative process*. Boston, MA: D.C Heath & Co Publishers.

Edwards, S. H. (2004). Using software testing to move students from trial-and-error to reflection-in-action. *Computer Science Education*. 26-30. https://doi.org/10.1145/971300.971312

Engkur, K., Supriyatna, A., Kholid, D. M., & Abdullah, F. (2019). The technique of playing sundanese gamelan made from a black bamboo resonance. *Proceedings of the Internasional Conference on Arts and Design Education 2018*. *255*, 53-57. https://doi.org/10.2991/icade-18.2019.12

Fastl, H. (2013). *Basics and application of psychoacoustics*. Acoustical Society of America. https://doi.org/10.1121/1.4800482

Garbett, D., & Ovens, A. (2018). *Pushing boundaries and crossing borders, self-study as a means for researching pedagogy*. Creative Commons Attribution 4.0 International.

Gerd, G. (2008). *Virtual gamelan graz rules, grammars and modeling*. Shaker Online. *https://supercollider.github.io/book/2008/12/11/a-new-book-virtual-gamelan-graz-rules-grammars-modeling*

Gray, C. (1996). *Inqury through practice : developing appropriate research strategies.* No Guru, No Method. http://carolegray.net/Papers%20PDFs/ngnm.pdf

Hamdan, S., Musib, A. F., Musoddiq, I. A., & Wahid, H. A. (2019). Some studies on the understanding the different tones quality in a bonang set. *Journal of Engineering Science and Technology*. *14*(4), 1960-1973.https://www.researchgate.net/publication/346444004_SOME_STUDIES_ON_THE_UNDERSTANDING_THE_DIFFERENT_TONES_QUALITY_IN_A_BONANG_SET

Hamdan, S., Musib, A. F., Musoddiq, I. A., & Sawawi, M. (2020). Timbre spectrum of gamelan instruments from four Malay Gamelan ensembles. *Pertanika Science & Technology*. *28*(2), 459-476. https://www.researchgate.net/publication/346444198_SCIENCE_TECHNOLOGY_Timbre_Spectrum_of_Gamelan_Instruments_from_Four_Malay_Gamelan_Ensembles

Hummel, Z. (2016). *Audio software (vst plugin) development with practical application* [Honor's thesis, Western Michigan University]. ScholarWorks. https://scholarworks.wmich.edu/honors_theses/2688/

Khafiizh, H.,& Mustafa, K. (2016). A method for automatic gamelan music composition. *International Journal of Advances in Intelligent Informatics*. *2*(1), 26-37. https://doi:10.26555/ijain.v2i1.57

Knoblauch, H., Schnettler, B., Raab, J., & Soeffner, H. G. (2006). *Video-analysis: methodology and methods*. Peter Lang.

Korthagen, F. (2011). Making teacher education relevant for practice: The pedagogy of realistic teacher education. *Orbis Scholae. 5*(2). https://doi.org/10.14712/23363177.2018.99.

Leblanc, S. (2018). Analysis of video-based training approaches and professional development. Society for Information Technology & Teacher Education. *18*(1), 125-148. https://www.learnchtechlib.org/primary/p/174355/.

Lusi, W., & Yudhiakto, P. (2017). Perbandingan hasil eksperimen superposisi gelombang bunyi bonang barung secara simultan dan mixing berbantuan audacity dan matlab. *Spektra: Jurnal fisika dan Aplikasinya*. *2*(1), 61-66. http://doi.org/10.21009/SPEKTRA

Lydia, A. (1996). "Merapi": a composition for gamelan and computer-generated tape. *Leonardo Music Journal. 6,* 7-14. https://doi.org/10.2307/1513298

Matthews, C. M. (2014). *Adapting and applying central Javanese gamelan music theory in electroacustic composition and performance* [Phd's Thesis, Middlesex University]. https://eprints.mdx.ac.uk/14415/

Matthews, C. (2018). *Algorithmic thinking and central Javanese gamelan*. The Oxford Handbook of Algorithmic Music. Oxford University Press.

Meizan, S. (2018). *Proses rekaman gamelan pertrack, no metronome* [Video]. YouTube. https://www.youtube.com/watch?v=9SolTuU6y4I

Miklaszewski, K. (1989). A case study of a pianist preparing a musical performance. *Psychology of Music and Music Education*. *17*, 95-109. https://doi.org/10.1177/0305735689172001

Mutagi, R. N. (2004). *Understanding the sampling process.* https://researchgate.net/publication/230813029

McGuire, S., & Pritss, R. (2007). *Audio sampling a practical guide*. Focal Press United Kingdom (1st ed.). Routledge.

Jaafar, S. (2017). Lestari muzik Johor sepanjang zaman. *International Conference on Local Knowledge.*
https://umexpert.um.edu.my/public_view.php?type=publication&row=Njk2Mzc%3D

Schon, D. A. (1987). *Educating the reflective practitioner: toward a new design for teaching and learning in the professions*. Jossey-Bass Higher Education Series.

Shafik, M., Jeroen, V. M. & Stewart, J. (2014). *The rough guide to Bali and Lombok* (8th ed.). Rough Guides.

Sheppard, H. M. (1967). Joget gamelan terengganu. *Journal of the Malaysia Branch of of the Royal Asiatic society, 40*(1), 149-152). http://www.jstor.org/stable/41491912

Smith, H., & Dean, R. T. (2009). *Practice-led research, research-led practice in the creative arts* (1st ed.). Edinburgh University Press Ltd.

Stenhouse, L. (1975). *An introduction to curriculum research and development.* Heinemann London.

Tjahyanto, A., Suprapto, Y. K., Wulandari, D. P. (2011). Model analysis-by-synthesis aplikasi pembangkit suara gamelan sintetik. *Seminar Nasional Aplikasi Teknologi Informasi*. https://journal.uii.ac.id/Snati/article/view/2226/2171

Young, H. P. (2009). Learning by trial and error. *Games and Economic Behaviour*. *65,* 626-643. http://doi.org/10.1016/j.geb.2008.02.011