

ARTICLE

## Establishing Communal Constructivism as an Appropriate Pedagogy for Virtual Reality (VR) Technology

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## ABSTRACT

As educators explore the use of virtual reality (VR) technology for education, there is an increased need to deliberate which pedagogical methods offer opportunities for doing more than just replicating the conventional classroom by leveraging the distinctive features and potential offered by the technology.

This research proposes communal constructivism as a viable pedagogy in the technical and vocational education and training (TVET) context. This approach, supported by VR technology, was implemented to train students in the concept of the aircraft Instrument Landing System (ILS) as covered in one of the Institute of Technical Education (ITE)'s aerospace avionics modules.

Two groups of 32 learners participated in the study in which their learning experiences were analysed. Data from surveys, semi-structured interviews and observations were examined to ascertain participants' experiences and the outcomes of the proposed pedagogy, including the affordances of the technology to improve their learning.

The findings from the quantitative and qualitative data suggest that learners construct knowledge for their benefit as well as collaboratively as a group to improve their learning, as a consequence of the innovative approach.

**Keywords:** Communal constructivism, virtual reality, technical and vocational education and training (TVET), Institute of Technical Education (ITE), aerospace avionics, innovative pedagogy, student learning outcomes

## INTRODUCTION

Unlike institutionalised learning environments, virtual worlds offer educators and learners a flexible learning environment. Virtual worlds are immersive and engaging (Castronova, 2005), giving users the ability to interact as well as explore shared experiences devoid of needing physical co-existence. In addition, the use of collaborative learning in virtual environments has grown into a more successful operation through scaffolding of learning activities, as communication platforms offer numerous opportunities for collaboration using virtual reality (VR) technology (Minocha & Roberts, 2008).

Savin-Baden (2008) notes that the learning experiences recorded in virtual worlds are often lacking in pedagogical grounding and educators have reached a point where they must start looking at the pedagogical-technological relationship. One method is by considering the affordances of “virtual world” technology and exploring pedagogies that influence those affordances.

This study will first discuss the educational affordances of employing VR technology in the Institute of Technical Education (ITE), and describe communal constructivism as a pedagogy that could theoretically exploit such technology to create a positive learning environment for learners (Holmes et al., 2001). This is followed by a description of the research methodology that explores both the operation and outcome of the pedagogy. The results are then presented and the findings discussed along with their implications in order to demonstrate that communal constructivism can be established as a viable pedagogy for VR technology to improve learners’ learning experiences.

### *Problem statement and study purpose*

Researchers such as Holmes et. al. (2001), as well as Scardamalia and Bereiter (1994) have researched and exploited different communication platforms, taking into account immersive and collaborative approaches in learning. From a novel pedagogical perspective, they have identified two pedagogies—knowledge creation and communal constructivism—that could directly leverage the use of VR technology in education.

To create knowledge, learners must use authentic issues and problems, discourse, and mutual accountability (Scardamalia, 2002; Scardamalia & Bereiter, 2003, 2006). The emphasis is on the community knowledge building process. Communal constructivism strongly parallels and expands the fundamental processes of knowledge creation, with an emphasis not just on the construction of knowledge for present learners but also for potential learners (Holmes et al., 2001). Learning experiences created by one group of learners can be transferred to the next, stressing the use of past experiences shared by previous learners to influence future learners’ learning experiences.

This study aims to establish communal constructivism as a viable pedagogy for use in the ITE, with the expectation that this pedagogy will assist learners’ capacities for knowledge building and retention.

Introduced in 2008, the National ITE Certification (NITEC) in aerospace avionics is a two-year full-time course which aims to equip students with a spectrum of core engineering principles, trade-specific knowledge, electives and basic communication skills. One of the trade-specific modules, Aircraft Communication and Navigation System, includes a topic on the Instrument Landing System (ILS), which allows pilots to land their aircraft with the aid of instrument references. This module has been taught to more than 40 classes. The class consisted mostly of Normal Technical students with a yearly enrolment of 130 students.

The team, comprising staff from the Department of Aerospace Avionics and the ITE Academy, selected the training module for ILS as part of the current research. The ILS uses electromagnetic (EM) waves to guide an

aircraft to land on a runway. EM waves are produced by the motion of electrically charged particles and can travel through empty space as well as through air.

The topic on EM waves is a Physics topic, and is generally recognised as being a difficult subject to learn and teach (Mualem & Eylon, 2007; Mulhall & Gunstone, 2008). Generally, ITE students have difficulty understanding this abstract physics-based concept. Given the fact that the inability of students to comprehend these concepts would reduce their opportunity to develop free exchange of ideas and foster active learning (Dori & Belcher, 2005), the team implemented the pedagogical approach of communal constructivism to investigate and verify the hypothesis that this innovative solution will indeed enhance the students' learning experience. The following research questions and hypothesis were considered:

*Main research question*

Can communal constructivism help to improve students' learning experiences in the course for NITEC in Aerospace Avionics supported by VR technology?

*Hypothesis*

Communal constructivism can help improve students' learning experiences in the Aerospace Avionics course, supported by VR technology.

*Significance of the study*

This study is significant for the ITE's curriculum developers who establish and manage the curriculum and the teaching staff who deliver the curriculum. The results would also offer guidance to teaching staff on how they can conduct future lessons using communal constructivism as an appropriate pedagogy supported with VR technologies, while catering for the differentiated learning needs of students.

## LITERATURE REVIEW

### *Communal constructivism and its benefits*

Effective education is a procedure that involves the active participation of the schools, teachers, and students (Dagar & Yadav, 2016). The constructivists perceive that human beings actively receive information during the learning process. According to Khan (2017), human beings incorporate and hold new information to facilitate the development of their understanding regarding different situations.

Communal constructivism determines that information is perceived as a subjective and personal reality located inside people's minds. Therefore, through this pedagogy, learning occurs when people incorporate information and interpret events, which results in multiple interpretations of one situation. Hence, communal constructivism is a learning approach in which learners construct their own knowledge as a result of their experiences and interactions with others, and are afforded the opportunity to contribute this knowledge to a communal knowledge base for the benefit of existing and new learners (Holmes et. at., 2001).

Constructivism theory is beneficial when incorporated into vocational education training as it helps learners develop critical thinking. According to Kim (2010), the constructivism approach builds on the view that people produce knowledge culturally and socially in different environments to understand reality. Nzilano (2015) specifies that this approach helps learners in vocational institutions to acknowledge various complexities and presentations of perceptions from a wide range of information sources in the cultural context. Communal constructivism also fosters active cooperation, collaboration, and at the same time, creates an autonomous and uncompetitive setting. These settings support the occurrence of deep learning, while facilitating the co-construction of the learner's individual knowledge in group environments. Richardson (2003) notes that the

main focus of this approach in learning institutions is to consider how individual learners identify suitable learning methods in both individual and group settings. Similarly, this pedagogy supports a holistic orientation, authentic practice and awareness of context that are essential to learners in vocational institutions (Mezirow & Taylor, 2011). Moreover, Gu et al. (2011) argue that this theory ultimately fosters appropriate teacher-learner interaction with the goal of facilitating the practical construction of information and learning.

The critical features of communal constructivism, in combination with VR technology have been shown to be instrumental in improving the learning outcomes. Girvan and Savage's (2010) study, for example, recognised communal constructivism as a viable pedagogy to be utilised in the virtual worlds by leveraging the distinctive features and potential offered by the technology. The research used a case study approach in which the participants' experiences were examined. The outcomes indicated that learners collaboratively created knowledge for themselves as a group and for others to improve their learning in the virtual worlds.

Although the literature noted that communal constructivism, supported with VR technology, is suitable to be incorporated in teaching and learning, there are still limited studies from countries in the West, much less in Asia, available to establish the fact. Therefore, to address this research gap, the research team examined students of the ITE to determine the effectiveness of communal constructivism in improving their learning experiences supported by the VR technologies.

### ***Benefits and challenges of using VR technology***

Technology can be embraced to improve and enhance learning environments in many cases, and VR is one of the emerging technologies which is significant in improving the learning competency and levels of motivation of learners, especially for vocational education and training institutions (Sattar et al., 2019). VR technology has features that can display objects in 3D, making it easier for learners to understand and to be able to see all angles of something without leaving a classroom. Vocational training institutions typically aim at imparting knowledge as well as skills to learners, and VR technology easily enables such learning by experience (Sampaio & Martins, 2014). According to Sultan et al. (2019), VR technology offers learners a more interactive and engaging environment, enhancing their abilities to retain knowledge and acquire skills. Notably, VR technology simulates a real working environment and provides an important alternative where learning can happen in a safer environment as opposed to where learners have to present themselves physically. VR technology provides students with the opportunity to be corrected whenever they make a mistake (Pottle, 2019). Indeed, Wang et al. (2018) agree that VR technology improves the effectiveness of learning.

Despite the benefits of using VR technology, there are shortcomings. VR technology could reduce human interaction which are deemed essential for proper understanding. More importantly, learners may become over-reliant on VR technology where unique qualities and thresholds, such as the cognitive and evaluative dimensions of learners, might be compromised (Hall et al., 2019).

Although VR technology has several challenges, appropriate pedagogical strategies may still be employed to improve the learning outcomes. According to Shirazi and Behzadan (2013), standard methods that can be used to supplement learning technologies include evaluating group work, giving feedback, and administering examinations to assess the applicative, replicative, and interpretive learning process. Indeed, appropriate pedagogic strategies are crucial in improving the outcome of VR training. As in the context of vocational training institutions to supplement learning with VR technology, it would be wise to incorporate an appropriate pedagogy in classroom learning with VR technology to reap the maximum benefits from the two (Bricken, 2008). By employing a suitable pedagogy with VR technology, it is hoped this will encourage greater learner interaction as they are in charge of their own learning.

### ***Application of communal constructivism with VR technology***

The team sought to investigate how the application of communal constructivism could be greatly enhanced with time using VR technology in supporting learning. This is a process whereby learners create their knowledge and that of the learning community by being actively involved in the process (Al-khalifah & McCrindle, 2006; Mantovani, 2003). The team applied the six core principles of communal constructivism that were identified by Holmes et al. (2001) as well as Pountney and Aspden (2002) to facilitate learning through the use of adequate and significant problems to be addressed in a virtual setting. These six principles are outlined in Table 1.

Table 1

#### *Core features of communal constructivism*

<b>Features of Communal Constructivism</b>	<b>Perceived Educational Affordances of VR Technology</b>
1. Interaction with the environment to construct knowledge	The 3D representation of the flight indicators environment and communication tools afford a sense of presence, immersion, socialisation, and collaborative learning.
2. Active collaboration	
3. Engagement with knowledge construction	These affordances are leveraged to support interaction with the environment, active collaboration, and knowledge construction within the group.
4. Publishing of knowledge	The affordances of VR technology allow learners to publish the knowledge constructed by the group and this provides opportunity for transfer of knowledge to take place between groups.
5. Transfer of knowledge between groups	
6. A dynamic and adaptive course	The flexible and persistent nature of virtual worlds, combined with infinite build and rebuild opportunities in VR technology, allows activities to be dynamic and adaptive through the actions of learners.

## **METHODOLOGY**

### ***Sample and sampling***

The research methodology for this study was primarily a true experimental design. In our research, we focused on the second year Aerospace Avionics (AEA) students for our experiment. The AEA course was selected because it was one of the pioneer courses in the ITE to introduce VR technology in the practical lessons.

In total, there were 64 students enrolled in the course. This was more than sufficient to meet the recommendations by Creswell (2012) for the sample size of 15 participants for a group experimental design. Moreover, the large sample size has the potential of reducing the risk of sampling error. These 64 students had comparable demographic profiles such as age, gender, and grade point average (GPA) scores. They were randomly assigned to the experimental and control groups of equal size each ( $N = 32$ ).

### ***Biographical data of respondents***

Table 2 presents the respondents' biographical data. From the 64-student sample, nearly all were males ( $N = 56, 88\%$ ), while females made up the rest ( $N = 8, 12\%$ ). This distribution between male and female students is indicative of a gender gap in engineering courses as commonly seen in ITE.

The distribution of respondents in terms of age indicates that the majority ( $N = 61$ , 95%) fell within the ages of 17-18 years. Students aged 19 years and above were in the minority ( $N = 3$ , 5%). The students in the study were relatively young. They correspond to the age cohort of the education level in Singapore. This could be explained by the fact the majority of the students transited from the secondary schools after completing their Normal-level (N-level) education.

Table 2

*Biographical data of student respondents*

Variable	Frequency	Percentage (%)
Gender: Male	56	88
Female	8	12
<b>Total</b>	<b>64</b>	<b>100</b>
Age: 17–18	61	95
19 and above	3	5
<b>Total</b>	<b>64</b>	<b>100</b>
Group: Control	32	50
Experimental	32	50
<b>Total</b>	<b>64</b>	<b>100</b>

### *Mean grade point average (GPA)*

The students from the control and experimental groups have near similar mean GPAs. The purpose is to ensure both groups have the same characteristics that form the baseline for an unbiased comparison (see Table 3).

Table 3

*Mean GPA of the groups*

Class	Score
A	2.651
B	2.653
C	2.745
D	2.892

After assigning students to the respective groups, we conducted the Levene's Equality of Variances Test to assess the equality of variances for a variable calculated (i.e., communal constructivism).

### ***Levene's Equality of Variances Test***

The Levene's Test is computed to check whether the experimental and control groups were homogenous and whether the variables were equally dispersed. The  $F$ -statistic is a value in a [regression analysis](#) to find out if the variance between two populations are significantly different (see Table 4). In general, if the calculated  $F$ -critical is larger than the study's  $F$  value, [the null hypothesis](#) cannot be rejected. There is a sufficient pre-condition to accept the null hypothesis that states the control and the experimental group of students were of a homogenous population with respect to their characteristics in the measured variables.

Table 4

*Levene's Equality of Variances Test*

Variable	Mean	df	$F$ -ratio Critical	$F$ -ratio	Level of Significance
Item 1					
Control	2.71			1.39	
Experimental	3.29				
Item 2					
Control	2.74			1.33	
Experimental	3.13				
		31	1.84		<b>0.05*</b>
Item 3					
Control	2.81			1.53	
Experimental	3.29				
Item 4					
Control	2.77			1.27	
Experimental	3.23				

\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

After establishing the homogeneity of variance for the groups of students, we conducted the analysis to ascertain the extent of impact of communal constructivism in class lessons.

### ***Research design***

For the experimental group, the students attended lessons based on the communal constructivism approach (i.e., the treatment). As for the control group, the students received no treatment. Summative assessment was conducted at the end of each lesson, and independent samples  $t$ -tests were performed to determine any significant differences in the outcomes between the groups. Surveys, interviews, and direct observation were implemented and empirically appraised (see Figure 1).



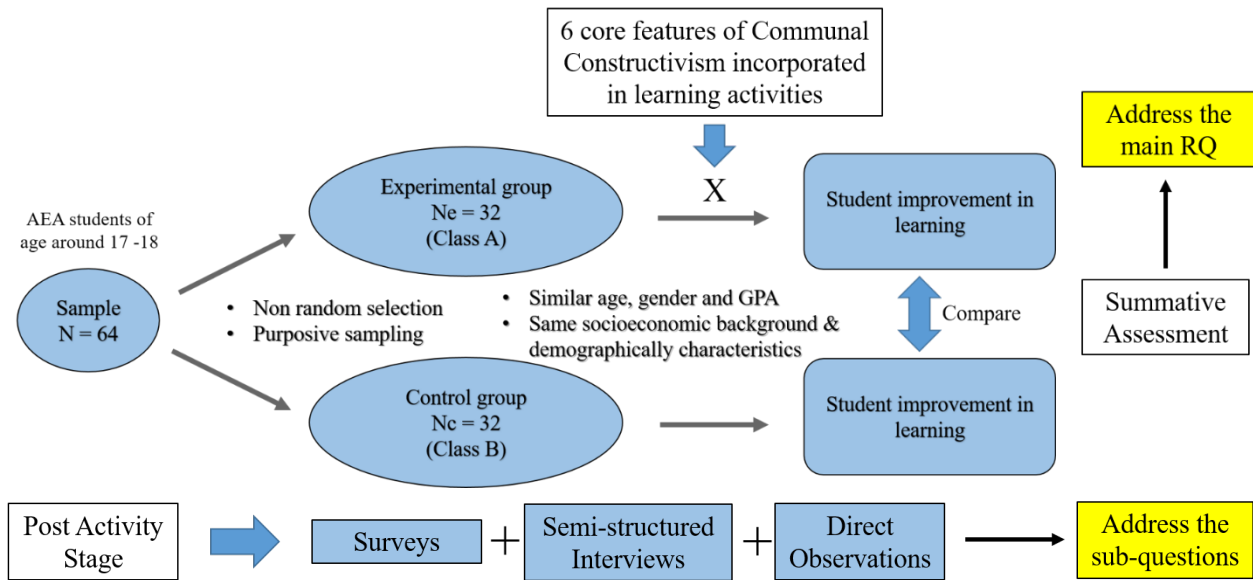


Figure 1. Research methodology

**Data sources and data collection**

The process of data triangulation was used to improve the credibility and validity of the study. Multiple data collection methods were deployed in the study as shown in Table 5 below.

Table 5

Primary and secondary data sources

Primary Data Sources	Secondary Data Sources
1. Results of the Summative Assessment	1. GPA – from ITE Student Academic Profiles
2. Surveys – via Google Forms	2. Age, gender, socioeconomic backgrounds based on ITE Student Profile Report from the School
3. Semi-structured Interviews – using the Interview Protocol	
4. Direct Observations – using the Lesson Observation Checklist	

Firstly, one of the primary data was the scores obtained after conducting the summative assessment ([Appendix A](#)) by using an evidence collection matrix created specifically for the study.

Another primary source of information was the results from the closed-ended questionnaires (seven questions) in the survey ([Appendix B](#)). The questionnaire was designed via Google Forms.

A third form of data collection was semi-structured interviews ([Appendix C](#)). Face-to-face interviews were conducted and the feedback transcribed. The participants were given both open-ended and closed-ended questions to address. During the interviews, the participants were requested to share any experiences that had contributed to their understanding of learning in their respective learning activities.

The fourth data collection was through lesson observations. During the observation sessions, the behaviours, actions, and reactions of the learners—verbal and non-verbal—were documented as field notes ([Appendix D](#)).

### ***Ethical considerations***

Among the ethical considerations for this study, only students in the experimental group received the treatment. They were briefed about the study and gave consent to participate in the research.

(Note: Following the completion of the research, the other class of the Aerospace Avionics course also received the same treatment so that all students enrolled in the module would benefit from the new pedagogical approach).

### ***Project schedule***

The study spanned across 24 weeks during the school term: June to November 2020 ([Appendix E](#)).

### ***Data analysis***

The research study employed both quantitative and qualitative techniques (Figure 2) to analyse the data collected to address the research question and hypothesis. A further elaboration of the quantitative and qualitative techniques is presented as follows:

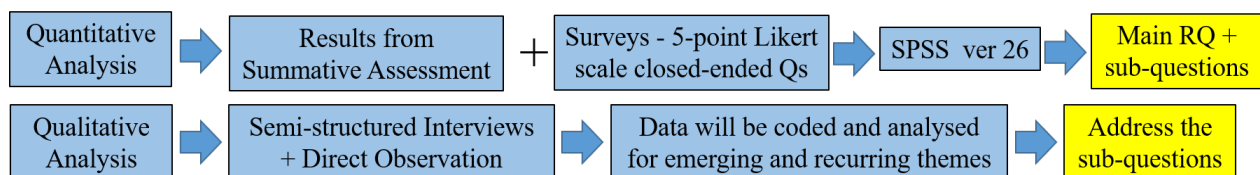


Figure 2. Quantitative and qualitative analysis

#### ***(i) Quantitative analysis***

The quantitative technique would allow the team to break down the data into parts for statistical analysis to objectively answer the research question “Can communal constructivism help improve students’ learning experiences in the course for NITEC in Aerospace Avionics supported by VR technology?” (Creswell, 2012).

Using the IBM SPSS statistical software, independent sample *t*-tests were conducted based on the results of the summative assessments to determine whether there were any differences in the learning outcomes between the control and experimental groups. Using a 5-point Likert scale, a students’ survey was also conducted to solicit feedback on their perceptions of their learning experiences.

#### ***(ii) Qualitative analysis***

Transcripts from the interviews and lesson observations were compiled and checked for analysis. During the analysis, themes were identified. The team members analysed the data for themes using text analysis and interpreting the larger meaning of the findings. Each member independently coded each interview line-by-line systematically. Next, they met on several occasions to discuss the codes, identify emergent themes, and reach concordance on the development of themes that represent the study’s findings. The themes highlighted the participants’ expectations and learning experiences based on communal constructivism, supported by VR

technology. Huang and Liaw (2018) assert that the themes provided answers for the study about how particular learning results were compiled during the learning process. The findings, based on participants' perspectives, would support the findings from the quantitative analysis.

## FINDINGS AND DISCUSSION

The next sub-section presents the results of the quantitative analyses. Following, the qualitative findings are presented to supplement the quantitative results. These findings form the overall perspectives of the theoretical knowledge and empirical evidence relating to the practice of communal constructivism in a TVET context.

### *Mean difference between control and experimental groups (Summative achievement test)*

A summative achievement test was administered to both groups of students. From Table 6 below, it was observed that a positive mean difference between the control and experimental groups for the four items assessed in the ILS learning activities was derived. The preparation and set-up of the ILS ramp tester, based on the technical manual, had shown the highest positive mean difference among the rest of the mean differences. In other words, students were able to select the correct model of the ILS ramp tester and checked for any anomalies on the LED displays and antenna. This is vital, as it is the first step towards performing an operational check on an ILS system in the aircraft.

If the  $p$ -value is less than significance level ( $p = 0.05$ ), the null hypothesis can be rejected. The independent samples mean difference test ( $t$ -test) that assumed unequal variances (because of the instructional intervention to one of the groups) between the two score distributions, resulted in a statistically significant difference. This reveals the presence of significant achievement variation between the two groups after the implementation of the new pedagogical approach. This is considered as a satisfactory condition for accepting the alternative hypothesis that states there is a statistically significant difference regarding the learners' experiences. All in all, the results verify that the introduction of communal constructivism has helped improve the students' learning experiences in the Aerospace Avionics course, which is translated to them achieving better performance in their class assessments.

Table 6

*Comparison of control group ( $N = 32$ ) and experimental group ( $N = 32$ ) in the results of the summative assessment*

Group	Mean Score	Mean diff.	T-value	df	Assumption	Sig.	Remarks
Cont. (1)	2.71		3.56			<b>0.001***</b>	
Exp. (1)	3.29	0.58					
Cont. (2)	2.74		2.83			<b>0.006**</b>	
Exp. (2)	3.13	0.39		62	Unequal variances		<b><i>There is statistically significance difference.</i></b>
Cont. (3)	2.81		3.20			<b>0.001***</b>	
Exp. (3)	3.29	0.48					
Cont. (4)	2.77		3.36			<b>0.001***</b>	
Exp. (4)	3.23	0.46					

*\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$*

Next, we analysed the students' survey to find out about their learning experiences from the learning activities regarding the aircraft ILS.

### *Students' survey on perception of their learning experiences*

Table 7 shows the percentage of students who selected either "Agree" or "Disagree" for the individual items. As the data revealed, 63% of students acknowledged the learning activities had helped them in their own learning. 72% agreed that the learning experiences they had gathered during the activities with their peers enhanced their understanding. 75% of students found that the learning activities on aircraft ILS enabled them to be collaborative with their peers on their learning. 78% of them agreed that sharing their learning with peers allowed them to understand the subject better. 81% of the interviewees realised that the new pedagogical approach enabled them to relate what was learnt to real-life examples. This could be due to the active participation of students in the class and positive engagement between the lecturers and the students on the topics concerned. 78% of the interviewees responded that the knowledge and skills acquired from the activities had garnered their confidence to work on an actual aircraft. 72% of students revealed they would continue to apply what they had learnt in ITE to the future workplace. All in all, the implementation of communal constructivism has benefitted the students, by helping them understand the concepts of the aircraft ILS as they share their knowledge with each other; creating better working relationships as they work with their peers; and raising their confidence to work on the actual aircraft system as they would have a better grasp of the skills and knowledge acquired.

Table 7

*Students' perceptions of their learning experiences following the learning activities in ILS using the VR technology (Experimental group: N = 32)*

No.	Survey Items	Mean	SD	Agree (%)	Disagree (%)
	<b>The learning activities on aircraft ILS:</b>				
1	have helped me understand the concepts easily on my own.	2.81	0.74	62.5	37.5
2	have better helped me understand the concepts together with my peers.	3.25	0.88	71.9	28.1
3	have enabled me to collaborate with my peers on my learning.	3.19	0.82	75.0	25.0
4	has allowed me to share my knowledge with my peers.	3.25	0.80	78.1	21.9
5	have enabled me to relate what was learned to real-life examples.	3.34	0.79	81.3	18.8
6	The knowledge and skills I gained on aircraft ILS from the learning activities have made me more confident to work on the actual aircraft system.	3.28	0.81	78.1	21.9
7	I will continue to apply what I have learnt from the learning activities to ensure I constantly add to my knowledge and improve my skills to suit the dynamic working environment.	3.09	0.82	71.9	28.1

Following the quantitative data collection, we proceeded to conduct qualitative data collection: 1) Interviews with the students and 2) Lesson observations of the students engaged in class activities.

### *Interview excerpts*

As suggested by Krueger (1994), the size of effective focus groups is usually between 6 to 12 participants. Based on this understanding, the team selected a total of eight students for the interviews. The small group size would allow each participant to share his/her experiences or views of communal constructivism. Below are samples of the interview extracts from the students:

“...the use of VR goggles allows me to understand how the approach of an aircraft works in the perspective of a pilot and in the airfield.”

“...the simulation of the aircraft landing with the use of aircraft instruments has deepened my knowledge of this topic in Aircraft Communication and Navigation System.”

“...the simulation provided by the localiser and glide slope in the training package has motivated me to share my knowledge with my peers.”

“...the lively engagement on case study about the use of instrument landing system that interferes with Malaysia’s airspace has fuelled my understanding of the importance on the use of appropriate flying and landing flight paths in a country’s airspace.”

“... the sharing from other groups has propelled my learning about the possible resolutions on the controversy between the two countries Singapore and Malaysia.”

The interview extracts revealed that the students seemed to perceive the use of communal constructivism in their training positively. In their responses, they described the use of VR technology coupled with active engagement and collaboration between peers while working on realistic topics, had motivated them to share their views. An example is the class discussions covering a news article on the use of ILS in Singapore that became a subject of dispute by their Malaysian counterpart (Mokhtar, 2018). Based on students’ prior knowledge, they participated actively in discussions, thus promoting learners’ deeper knowledge for the topic.

### *Lesson observations*

The lesson observations were pre-scheduled and focused on the learners’ engagement and learning activities in class. During the observations, the intent was to determine if students participated actively individually and in groups, and how they interacted in the course of the lesson. The lecturers followed standard procedures based on the prepared lesson plan template. First, they introduced the lesson objectives, type of formative assessment and the assessment criteria. Next, they proceeded with the revision on the previous lesson and introduced the new lesson in context. Case studies covering applications of ILS were employed and the class was divided into groups of three to four. Students would then deliberate based on what they had learnt earlier on this topic and proposed possible solutions to enable the aircraft to take off and land safely.

The observations revealed that during many of the sessions, the majority of students were seen taking notes, searching for information on the internet, discussing possible flight scenarios and presenting them to the class. Learners expressed great interest on the case studies during the discussions with their peers. Also, it was also observed that the male students participated more actively than female students.

### ***Summary of findings***

As earlier discussed in the literature review, communal constructivism, in combination with VR technology have been shown to be instrumental in improving the learning outcomes (Girvan & Savage, 2010). Our research has proven this point, as the findings have shown that the constant interaction between lecturers and students, and between peers, have improved their learning abilities towards the use of the ILS in aircrafts. Furthermore, the opportunity to share their views in the classroom has provided valuable lessons learnt among the students. This transfer of knowledge between groups created a dynamic learning environment for lifelong learning. The shortcomings of using VR technology, such as reduced human interaction, which can compromise cognitive and evaluative dimensions (Hall et al., 2019) can be overcome with the use of communal constructivism as a viable pedagogy. Based on both the quantitative and qualitative analyses, the team summarised the findings from our study in Table 8 below.

Table 8

#### *Summary of findings*

Research Question	Summary Findings
Can communal constructivism help improve the students' learning experiences using VR technology in the course for NITEC in Aerospace Avionics?	<ol style="list-style-type: none"> <li>1. The learning experiences of the participants are positively affected by the use of communal constructivism, supported by VR technology learning process.</li> <li>2. Participants testified that there was a sense of interaction and collaboration among fellow classmates during the learning process as their lecturers engaged them using communal constructivism, supported by VR technology.</li> <li>3. Participants acknowledged that communal constructivism was an effective pedagogy in the learning process through VR technology. Such approach has enabled them to relate what was learned to real-life examples, while helping them to gain more confident to work on the actual aircraft system in their future employment.</li> </ol> <p>Furthermore, they professed they would continue to apply what they have learnt from the learning activities to ensure they constantly add to their knowledge and improve their skills to suit the dynamic working environment.</p>

### **CONCLUSION AND LIMITATIONS OF THE STUDY**

The study has met the research purpose to establish communal constructivism as a viable pedagogy for use with VR technology, resulting in knowledge building and retention of skills for the learners. Although the approach was introduced in the course of NITEC in Aerospace Avionics supported by VR technology which covered a very specific topic on the aircraft instrument landing system (ILS), we believe the use of communal constructivism as an appropriate pedagogy to help improve students' learning experiences is feasible not only in fields of study that cover electronics subject matters, but also in other non-engineering fields of study that involve collaborative approaches in learning and knowledge creation. In other words, lecturers and researchers in other institutes of higher learning can first consider applying the general principles of communal constructivism in their respective fields of study. Subsequently, in a next step to the teaching process, where applicable, they can consider the use of VR to support communal constructivism to further enhance the quality of teaching to engage their students at a deeper level.

The current study was limited to the context of learners in ITE. The research also assumed that every participant would provide “correct” feedback in response to the quantitative and qualitative data collection. Nor did our research design isolate other variables, for example, learners with special education needs, the variances in the classroom dynamics or other learner diversity which might influence the general learning experience. Another concern is the ‘novelty effect’ of participants’ learning using the VR equipment. Hence, the team will continue to conduct more research on the use VR technology to support communal constructivism. In time to come, this will be our common teaching practice and eventually will dispel the ‘novelty effect’. We will also consider using other media such augmented reality (AR) or mixed reality (MR) to determine if learning is interchangeable with VR. Nonetheless, the study delivered a point of reference for other researchers that may have an interest in applying communal constructivism as an innovative pedagogical approach in their lessons.

As for this research, incorporating the features of communal constructivism in the learning process using VR technology has positively improved and enriched learning for the students. Hopefully, this innovative pedagogy can be introduced in the future training processes in the ITE. On the whole, the ITE as an innovative technical and vocational institution will break new ground and pioneer novel learning strategies to engage students in a more authentic learning environment. This will pave the way for progressive curriculum design and development in more programmes to enhance the training of the next generation of ITE students. Eventually, they will be better prepared to perform confidently and competently, and to excel in their tasks when they join companies in the future.

#### **APPENDIX A. [Summative Assessment and Evidence Collection Matrix](#)**

#### **APPENDIX B. [Questionnaire](#)**

#### **APPENDIX C. [Interview Protocol](#)**

#### **APPENDIX D. [Lesson Observation Template for Research Team](#)**

#### **APPENDIX E. [Project Implementation Plan](#)**

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