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Effect of personality on felling machine operator performance: Case study using a John Deere Simulator

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EXECUTIVE SUMMARY

This project aims to discover whether personality impacts the performance of forest machine operators. The goal of this final year student project was to provide a better understanding of the operator's personality and the link to more efficient machine utilization. The insights from this study could be used to help put the right people into the right jobs, and target their future training focuses.

A John Deere felling machine simulator was used to capture data and help standardise the working environment for the volunteer operators. Data from the simulator was combined with personality data that was collected using the Myers Briggs Type Indicator (MBTI) test. The MBTI gives results on 4 dichotomies which show the characteristics of an individual's personality type.

There were 32 volunteer operators primarily from engineering and forestry science degree programs; 18 of them were male students and 14 female. They came from a variety ethnic backgrounds including NZ Europeans, Asians and Pacific Islanders. After the initial tests some of the best performers were asked to return to test for consistency.

Analysis of the data found that the two dichotomies which have a significant impact on the performances were Mind and Nature. In the initial trial, people with a Thinking personality type outperformed people with a Feeling type in most scoring parameters.

There were some limitations and potential improvements that could return a better result in the future studies. Improvements would include a larger population size, improvements on the task difficulty, personality test result details, parameters from the scoring form and a larger time scale for better consistency test.

INTRODUCTION

In order to maximise the utilization of operators on the work site, management teams should have a good understanding of each of their team members capabilities. The forest industry now relies heavily on mechanization and operator training is key to ensuring efficient operations.

Felling machines are the starting point of the tree harvesting process and it has a direct impact on the daily production of the harvesting operation. It was therefore decided to use the felling machine as the focus for this study. The felling machine operators face challenges such as on-site safety hazards, isolation and loneliness, repetitive tasks and constant decision making. For these reasons, training is usually considered one of the main tools for increasing the operator's performance. However, the operator's performance may depend on aspects such as aptitude and attitude. One aspect that is usually not considered when assessing the performance of the operator is their personality, yet personality is strongly linked to aptitude and attitude.

Personality type can be ascertained by doing the Myers- Briggs Type Indicator (MBTI) test. The MBTI was constructed by Katharine Cook-Briggs and her daughter Isabel Briggs-Myers, it was based on the conceptual theory proposed by Carl Jung but more developed on the structure. The MBTI is an introspective self-report, indicating differing psychological preferences in how people perceive the world around them and make decisions. The theory highlights that the seemingly random variations between people's daily behaviour is actually following some order, based on how they think and their preferences on making decisions. The primary aim of Isabel Briggs-Myers and her mother was to make the insights of the psychological theory more accessible and understandable to groups and individuals.

According to Myers' personality theory, one's personality can define where they get their energy and motivation from, the way the person plans the work and how the person makes decisions. There are four dichotomies in the MBTI, which can form 16 different personality types. The result simply shows the person's preference over another, it doesn't measure their aptitude. The MBTI was built for the working population, it can be used to support the person's future work focus and potential weakness that could be improved. While it has flaws, it is said to be one of the most reliable assessments. Figure 1 below shows the 16 possibilities of the MBTI personality types.

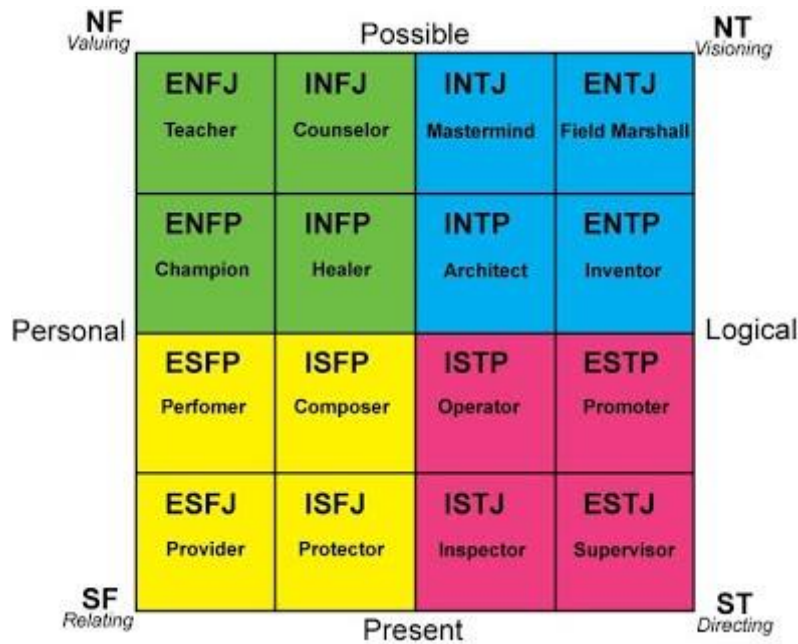


Figure 1: The 16 personality types from MBTI

This project used the John Deere forestry machine simulator to provide the volunteers operators with an environment close to a real forest harvesting operation; which allowed these volunteers to participate in the experiment in a safe manner. The aim of the project was to investigate the relationship between an operator’s personality and their performance. If personality proved to be a significant factor, the best set of personality traits for operating forest machinery could be further investigated.

LITERATURE REVIEW

Research conducted by Wilson (2017) states the millennial problem of the forest industry is that young people are not attracted to a life in the forest as it perceived as difficult, dirty, dangerous and declining. The earnings from these jobs are not as high in comparison to previous times (e.g. in 1978 a forest worker without a high-school diploma could earn up to 40% more than the average wage). As such the question is if there are improvements to be made?

There have been improvements in safety and the working environment, therefore the work has been getting less dangerous; which leads to higher job satisfaction. However, some state that the challenges in attracting new workers are still critical and keep growing. The development of the forest industry work place and culture is very important. However, there haven’t been many studies that focus on the soft skills and the benefits they can bring to the forest industry. In contrast, studies in business cases have said that personality types are one of the most noticeable factors to build an effective and productive working environment.

There are 16 different combinations of personality types, the personality combinations are identified by four dichotomies which are: **energy, mind, nature, and tactics**. There is an extra factor which is identity, it will not change the personality type, but will assist the readers to gain more information. The first dichotomy is **energy** which includes two possibilities, which are introvert

and extravert; not just by the simple identification of if the person is ingoing or outgoing, it also takes consideration of how these people energize themselves while working. The second dichotomy is **mind** which can include intuitive and sensing; it shows how people interact with the environment and how they gather the information from outside. The third dichotomy, **nature**, is made up of thinking and feeling; where thinking is the type of people who make their decisions by logic and they always prioritise rules over their heart's feelings. Whereas, the feeling type make decisions by thinking about people who are involved in this case and follow their hearts. The fourth dichotomy is **tactics** which is made up by judging and prospecting; it indicates how organized people are. People with a judging type like to plan ahead and stick to their plans, while the prospective type of people are more flexible and always look out for more opportunities. The extra factor is identity, which consists of either assertive or turbulent. Turbulent people are identified as self-conscious and more sensitive to stress, whereas the assertive is more stable with their emotions. This study focussed on the first four dichotomies, as the aim was to look for the best personality type for the highest performance with a forest felling machine simulator.

Wood (2017) stated that the unemployment level is at its lowest rate in 18 years and it is important to find the right candidate across various aspects of performance and personality. Soft skills and cultural fit have been drawing some attention from employers while making a hiring decision. The article uses introvert type and extravert type as an example to discuss the strengths and weaknesses of each type. Furthermore, it mentions how they get their energy while working, shows some predictions of how they will perform at workplaces, how they will handle different working tasks and how they will have their impacts on the job. The article concludes by talking about the potential challenges these employees may face later on in their career and provides potential solutions for these challenges.

Root (2018) noted that workplaces are dictated not only by policies, as the personalities of employees are also important. The managers should gain a good understanding of each team member's personality and make good use of them to grow the company and move it forward. The author explains how personality can have an impact on workplace performance by areas like creativity, retention, teamwork, and productivity. Different personality types bring more potential to the workplaces, as they can help to uncover ideas of which have not been thought of previously.

Zimmer (2018) said that hiring decisions nowadays are not only based on the skills that the potential employees majored in, but that there has also been more attention on personality traits, such as perseverance and conscientiousness. Zimmer also mentions there is no perfect type of personality that can thrive in the workplace as sometimes the workers have to act out of their real character just to fit in the working environment. It is more dependent on the managers to make good use of the "Big Five" personality dimensions.

The famous "Big Five" personality factors (Srivastava, d.n.) are extraversion, agreeableness, conscientiousness, neuroticism and openness to experience. They are five broad factors of personality traits which are an empirically based phenomenon, not a theory of personality. The "Big Five" factors were discovered through a statistical procedure called factor analysis, which was used to analyse how ratings of various personality traits are correlated in humans. This 'Big Five' factors have a large number of samples and have proved their reliability overtime.

There have been studies about using simulators to do training and with a purposeful designed experiment the data should be fairly reliable. As the Virtual Reality (VR) technology is growing

towards maturity, there have been studies about using the VR machine to train students (Lapointe, 2000), and the results showed that students with VR training become more familiar and learned faster when operating the actual machines than students who have been trained with traditional methods. There have also been studies about building a real-time simulator (Papadopoulos & Gonthier, 2002) which could increase the reliability of the simulator experiments.

In this study, a John Deere simulator (WCFD 2002) with a 1270E wheeled harvester was used in conjunction with a designed experiment for volunteer operators to perform a targeted tree felling and processing exercise.

There have been examples of success uses of simulators in using forestry applications. For example, a program named SEESAW, was a computer simulation program for the sawing of pruned logs. It was developed to aid in the evaluation of the pruned log types and to provide a tool for analysing their interactions with various saw patterns and sawmill practices (Todoroki 1987). The study showed if the computer program was set up correctly with the right scope of the experiment, it was possible to use the simulator to get good practical data.

There are other personality testes which have some areas overlap with the MBTI, here are some examples of some popular personality tests and why the MBTI was chosen to be the one test for this project:

Activity Vector Analysis (AVA) is a work-related system of behavioural assessments tool, it has been widely recognized for its accuracy, validity, simplicity and utility. It gives some explanations on why people behave differently while completing the same task, this allows the managers to coach, lead and develop their employees. AVA summarises the behavioural demands of specific positions and tasks, which helps the company to put the right person onto the right task.

The “Big Five” personality traits, also known as the five-factor model (FFM) and the OCEAN model, which is a taxonomy for personality traits use descriptors of common language and therefore suggests five broad dimensions commonly used to describe the human personality and psyche. The “Five” include: openness to experience, conscientiousness, extraversion, agreeableness and neuroticism. These factors describe the participant’s personality and way of thinking and doing things, but some psychologists have disagreed with the model. They feel it neglects some domains of personality, Dan P. McAdams called the “Big Five” a “psychology of the stranger”, as they don’t reflect the aspects that are more privately held and more context-dependent.

The more recent and comprehensive studies have provided evidence for six large groups rather than five. The HEXACO model of personality structure is a six-dimensional model of human personality that was created by Ashton and Lee. The theory is made by several cross-language studies including European and Asian. These six factors include Honesty-Humility, Emotionality, Extraversion, Agreeableness, Conscientiousness and Openness to experience (HEXACO). There are 4 facets of each factor. The H factor can be seen as a factor that has been partially included in the “Big Five’s” Agreeableness, as there is a close relationship between these two methods. The personality tests mentioned above, all have similar contents in them. They are different by the focus of the model, MBTI and AVA are more work environment related where the “Big Five” and HEXACO can be used in a wider range. The reasons why MBTI was chosen to be the official personality test for this study are both from the test itself and how it fits the best with the scope of this project.

The MBTI is the most popular personality test, as an experimental based theory, it has a large population who have taken the test. It is easy to access and free to take; the test takes 10-15 mins which can provide the high efficiency of the study. The focus is work environment related, it is straight-forward to understand the worker's behaviours rather than the person's behaviours. The insights of the theory is made easier to understand, which allows more people to understand them.

METHODOLOGY

A group of students was asked from the University of Canterbury to participate in this study. A total of 32 volunteering students responded positively to perform. These volunteers came from a range of study backgrounds, with high interest in participating in this study, and a similar number of both genders. The author acted as the supervisor of the study who was responsible for the volunteer's safety, gave support to volunteers when needed and looked after the lab environment.

The MBTI test was performed by letting people give their honest opinions on the prepared questions. These questions are prepared with psychological testing purposes and theories behind them, as they put the person into a self-reflecting imaginary zone. The questions asked people how they would react if some situations happen to them, or whether they agree on something. The answers provided to each question are answered with a scale that has three options agreeing with a statement (i.e. somewhat agree to strongly agree), three options disagreeing with a statement (i.e. somewhat disagree to strongly disagree) and an option to remain neutral. Some questions were asked multiple times but from different angles to get the full picture of people's personality type in some particular areas. It was clearly stated that the test should be taken honestly, and to try not to use the term neutral as it doesn't provide useful information.

The free public accessible online personality MBTI test (link: <https://www.16personalities.com/free-personality-test>) was used as the personality type measuring tool for this study. Each of the project volunteers was asked to take this under an environment where there were no outside interruptions, so they could focus on the questions. Volunteers also performed the test while alone, so they would be more likely to answer the questions honestly and independently. After completing the test, the results were sent back to the supervisor either online or in person.

The four dichotomies in MBTI are Energy, Mind, Nature and Tactics. There was also a fifth dichotomy, Identity, but as it had no impact on changing the personality type, it was not included in this study for further analysis. The section below breaks down the four dichotomies with further details and how they may have an impact on the forest machine operator's performance:

1. Mind - Extraverted or Introverted

Mind indicates how people interact with their surroundings, and how they can energize themselves. Introvert people get energy from the inside, while extraverted people gain energy by engaging with the outside world. Introvert people prefer to work alone, while extravert people perform better while in a team environment.

Potential impact that Mind has on the performance: Introverted people may suit the working environment better, as working in the forest in a felling machine can be seen as isolated from the

surroundings, the majority of working time they will be working by themselves. Extraverted people can bring some energy to the crew, they are more excited but need to be recharged by engaging with the surroundings. Extraverted people may find it challenging to stay focus and energized through the whole day. Therefore, introverted personality type is preferred, but when there are some cases that require a fair amount of team work, then Extravert personality type will be favoured as they are more likely to explain their ideas clearer and fit better in a team.

2. Energy - Intuitive or Sensing

Sensing type individuals are believed to be highly practical, pragmatic and down-to-earth. They tend to have strong habits and focus on what is happening or has already happened. They gain their information from what they actually see and touch. Intuitive type individuals are people who are imaginative, open minded and curious. They gain their information from their imagination, ideas and possibilities.

Potential impact that Energy has on the performance: Sensing people could do better operating felling machinery as it is a practical job; while Intuitive people should have a better understanding on the instruction handouts. They are less likely to make the mistakes as they can potentially learn from the best. Whereas, sensing people have better potential to improve with more practice.

3. Nature - Thinking or Feeling

Nature shows how people will make decisions and cope with their emotions. Another way of looking at this is where they set their priorities. Thinking people make decisions mainly through logic and rules, they do not let the emotions get in the way while making decisions. Feeling people make a decision based on emotion, based on what they feel they should do and who is involved in the situation.

Potential impact that Nature has on the performance: Thinking people should have a higher performance compared to Feeling, as they will more likely to stick to the operational requirements. The accuracy of the simulator representativeness of the felling operation will have an impact on the Feeling people as that can vary their sense of the assessment standards.

4. Tactics - Judging or Perceiving

Tactics reflects how people approach work, planning and decision-making. Judging people organize all of life events and as a rule, stick to the plan. Perceiving people are inclined to improvise and explore alternative options. Judging people could use the available felling zone space more effectively with more mature planning in their heads, while Perceiving people are less organized and plan as it comes, but could be more flexible.

Potential impact that Tactics has on the performance: Judging type people may make less mistakes, potentially work faster, as they are more focused and already have a plan in place. Perceiving people have more potential to be creative and could be more flexible with their work. They are less predictable but can bring some surprising ideas to the job tasks.

The next step was for participants (i.e. student volunteers) to undertake training to operate the simulator in the lab. This part of the study was tested and improved by the supervisor and his team to be task-specific and have the right scope for the study. First, the process started with a presentation on forest harvesting, basic information and a quick overview of the study. The purpose was to ensure that all the volunteers were on the same page of the knowledge about the study and forest harvesting and what exactly they would be doing.

Second, there was a tutorial on how to operate the John Deere simulator. Figure 2 below shows the equipment setup and handout instruction was also provided to for understanding (a copy of the handout can be seen in the appendix). The instruction highlighted the buttons that would be used for the simulator task, which helped set the focus and made the operating pad looks less complex. The instruction briefly explained the functions of the controls. Then, the supervisor gave a tutorial on how to operate the John Deere simulator by showing the volunteers in a practice program.



Figure 2: Basic control layout for John Deere forest machine simulator.

The third part of simulator training was a practice session for 20 minutes by the volunteers to get familiar with the controls. The supervisor logged into one of the training programs (JDTimberSkills), where there were plenty of exercises for the volunteer to practice felling and get familiar with the machine.

The fourth and final part of the training induction was to allow the volunteers to gain some familiarity in the real test mode by having three unrecorded trials. This was mainly due to the different performance judging standards between the practice and test modes and ensured a higher passing rate for volunteers.



Figure 3: A volunteer operating the simulator

Finally each volunteer operated the simulator in the actual test (Figure 3 above). Each of the volunteers had three trials and the best result was taken. More trials were performed if there was significantly inconsistent performance. Feedback was given after each trial to support the operators for more improvements. The feedback was only based on their operating performance, and did not impact their personality or thinking and planning in the future trials.

After all the participants finished their tests, data analysis was carried out to discover if there was a relationship between operator's performance and personality type by comparing the results from each personality field. If the person's personality was relatively consistent, then the best performers from each of the four of the personality fields were asked to do one more test on the simulator. The follow up test was to see if the conclusions from the data analysis were reliable and whether the personality could have a long term impact on the operator's performance.

Table 1 below, shows the 10 parameters that were measured during the test with their description of why they were chosen. Appendix 1 has the full description of each parameter and their scoring rules.

Table 1: Scoring form parameters with descriptions

	Parameters	Description
1	Felling Time (sec)	Total time taken to complete the felling component of the task, converted to a score out of 10. This is directly related to the operator's production rate & the operator's skill level. It also helps for production estimation from the management team.
2	Process Time (sec)	Total time taken to complete the processing component of the task, converted to a score out of 10. Similar to felling time, but also reflects the effectiveness of the felling plan and operator's control level after the tree has been harvested.
3	Stack Quality (Category 1-10)	If this is done well, the double handling time taken by the forwarder will be reduced significantly, which potentially increases the production of the next process (forwarding), and is also important for determining how efficiently an operator uses their space.
4	Saw Damage (Category 1 or 10)	Criteria from John Deere simulator that records frequency and severity of saw damage. This is critical both in financial and safety aspects. It adds extra cost to replace the saw, a blunt saw adds more uncertainties to the cutting task.
5	Machine Damage (Category 1 or 10)	Criteria from John Deere simulator that records frequency and severity of machine damage. Similar to saw damage but in a larger scale, machine costs more to fix and the related hazards are often closer to the operator.
6	Stump Height (Category 1-10)	Criteria from John Deere simulator that records the stump height after a tree has been felled. The bottom log has a high proportion of valuable wood and large diameter, if the stump is left too high, there is significant financial loss. The target trees for the test do not exceed the handling limit therefore, it is critical to cut trees low; also shows the skill level of the operator.
7	Boom Usage (Category 1-10)	The boom is the critical part of the felling machine, it is important to see how familiar the operator is with moving it. The boom control is observed by the supervisor both before and after each tree is cut and rated 1-10.
8	Simultaneous Boom Movement (Category 1-10)	Criteria from John Deere simulator that records the time and frequency of simultaneous boom movement during operation. The simultaneous movement is critical as it will use less fuel to do the same task, this shows the skill level of the operator.
9	Operator Skill Level (Category 1-10)	This is an overall view of the operator's skill on operating the machine by the supervisor, both from the speed of movements and the amount of control the operator has throughout the whole test. The supervisor then gives a score out of 10 to indicate the skill level.
10	Operator Performance (Category 1-10)	This is an overall view of the operator's performance. The two critical measures are skill (combined with the confidence and emotions) and the felling plan (the strategy that the operator has). By combining these elements together, one can discover if the operator sacrificed one less important element to improve the more important one.

The Test

The test was done on a built-in John Deere simulator training program (JDTimberSkills). It asked the operator to fell and process the trees in front of the machine (Forward Felling Module 1). Figure 4 below, shows the cabin view of the test mode. Due to volunteers' abilities and scope of the project, the original task was simplified, as some uncritical terms caused lower passing rates. The volunteers were asked to fell 2 target trees which are tree number 2 and 3 shown in the figure below, process them into their assigned log grades and stack the logs into piles somewhere suitable on the left side of the machine. The volunteers were then scored with the 10 different scoring factors (see a copy of the scoring form and scoring rules in the appendix), which helped to judge the performance by; time taken, operation performance, operator performance.



Figure 4: Cabin view of the simulator operating test

Explanation:

This was a two hour lab section, which consisted of a 20 minute individual personality test, a 15 minute presentation about forestry background by the supervisor, a 15 minutes tutorial on the basic felling machine operation training, a 20 minutes practice session and then use the rest of time to complete the actual test, some comments and recommendations were given after each trial to lead the volunteer for improvements.

There were 32 volunteers, which made the margin of error for this experiment to be 17.7 % (Niles, 2006). The larger the population the higher confidence of this experiment's results. Due to the scope of the project and time taken for each volunteer, 32 was an adequate sample size that allowed the author to make adjustments to the experiment.

The 20 minutes practice session on the simulator was decided by the author after several times of tests and practice with the team. It was decided that this amount of time was enough for the participants to gain enough familiarity of the machine and allowed the lab to flow fluently. It was

believed that the performance differences were due to the participant's ability which could be a reflection of the personality type.

The reason for making the practice non-structured (i.e. not specific tasks or scoring) was for participants to let go the constraints over their personalities, they would use their own thinking to come up with some practices that are most helpful to themselves on improving the machine operation.

The only requirement was for the laying of the logs to the left-hand side of the machine. This left the operator to identify where it was clear and safe enough to lay the logs. This allowed the personality to take control, either they would risk it by leaving them close for a faster processing time or drag them far to ensure a safe operation, to avoid potential machine damage. Figure 5 below, shows the opening spaces on the left of the machine; the unlimited space caused the volunteers to evaluate their plans.



Figure 5: Walk mode view for the test set up.

The best performers from each field of personality were asked to return and complete the test again. It was assumed that the best performer of the personality was the one who took the best use of that personality on completing this task. By calling them back after a period of time, it allowed the supervisor to judge if the previous results were consistent and reliable over time. To respect the volunteer's privacy, they were coded by initials (Appendix 2).

In a normal ground-based harvesting set up, the felling machine has the least interaction with the crew. Therefore the introverts should have a better advantage over the extraverts as they could motivate themselves alone and work better by themselves. The felling operations are practical, therefore it was more likely for people with a sensing personality type to perform better, and they are expected to have a higher skill level in getting the job done. The people with a thinking personality type are expected to have higher passing rates than people with a feeling personality, they are more likely to stick to the rules and make sure they get them right, but the feeling people may beat them by a faster speed as they don't normally have as much worry and concerns. People

with a judging personality type should have a more mature and strategic felling plan than the people with a prospective type, but not as creative on their felling plans.

According to the short analysis above, the best fit for the normal felling job was ISFP. As it should provide such characteristics like fast learner, high level of skills, creative and fast movements. Where if there are special environmental concerns then the best fit should be: ISTJ. When there is a priority shift, a thinking type of personality should be more reliable on applying these new requirements and more careful of their moves. The judging personality type will help them to have a more organized plan ahead to follow.

RESULTS

There were 32 University of Canterbury students who volunteered for this study, they were primarily from engineering and forestry science degree programs, 18 of them were male students and 14 female. They came from a variety ethnic backgrounds including 11 NZ Europeans, 12 Asians and 9 Pacific Islanders.

The distribution of volunteers for each personality dichotomy is shown in Table 2 below. For dichotomies like Mind and Tactics, number of members were similar on both sides. But in dichotomies like Energy and Nature, clearly one has more people than the other. This raised awareness while analysing the data.

Table 2: Personality dichotomies and the number of volunteers by category

Personality Dichotomies	Number of People by Category	
	Mind	E
	19	13
Energy	N	S
#	10	22
Nature	T	F
#	10	22
Tactics	P	J
#	16	16

Combining the category level rating, there were 12 different personality types who participated in this experiment. ESFJ, ISFJ and ESFP had the highest number of participants (Table 3).

Table 3: Personality types and the number of volunteers by each type

ISTP	2
ESFJ	5
INFJ	2
ESTJ	2
ESTP	3
ISFJ	4
ENFP	3
ENFJ	1
ESFP	4
INFP	3
ENTP	1
ISTJ	2
Total	32

Table 4 below, is the analysis of the study data for each scoring parameter. The statistical components were the mean value. Parameter 1 & 2 were measured in actual time in seconds while the rest of the parameters were category scores from 1-10.

The standard deviation and the standard error of the 10 scoring parameters are also presented. Results showed a low standard error for some of the parameters, which meant the data was reliable. Parameters 1 & 2 were more sensitive to the changes. There were some faster learners who could perform faster than other people and with a higher quality, but there was no one that seemed to be extremely slow (which could have been treated as an outlier).

**Table 4: Analysis of the experiment data by parameters
(Parameter 1 and 2 in seconds, other parameters in categories 1- 10).**

Parameter	Mean	SD	SE
1	29.1s	10.5s	1.9s
2	14.4s	5.7s	1.0s
3	5.94	2.06	0.36
4	10.0	0.00	0.00
5	10.0	0.00	0.00
6	9.75	0.43	0.08
7	7.66	1.38	0.24
8	5.50	1.84	0.32
9	7.75	0.94	0.17
10	8.28	1.33	0.23

The next section of the study investigated data by each dichotomy; to try and discover if there was a favoured type from each dichotomy.

Introvert vs. Extravert

There were 19 people with extravert personality (E) and 13 with Introvert (I) personality for this study. A quick scoring result analysis is shown below (Table 5).

Table 5: Result analysis for personality type E & I

Personality Type	Parameter	1	2	3	4	5	6	7	8	9	10
I	Mean	9.00	5.38	5.85	10.00	10.00	9.77	7.54	5.69	7.69	8.46
	SD	1.24	3.87	2.07	0.00	0.00	0.42	1.60	1.49	0.91	1.15
E	Mean	9.47	6.84	6.00	10.00	10.00	9.74	7.74	5.37	7.79	8.16
	SD	1.57	2.98	2.05	0.00	0.00	0.44	1.21	2.03	0.95	1.42

(I= Introvert, E= Extravert, SD= standard deviation, Units of all parameters in categories 1-10)

The Extravert personality type showed a higher average score in parameters like felling time (1) and processing time (2), whereas Introvert people showed a better result in simultaneous boom movement (8) and operator performance level (10). The results showed that extraverted people could fell faster and process faster than Introverted people, while Introverted people were better at machine operating.

Intuitive vs. Sensing

There were 22 volunteers with Sensing personality and 10 with Intuitive type for this study. There are a number advantages favouring people with a Sensing personality type. A scoring result analysis is shown in the Table 6 below.

Table 6: Result analysis for personality type N & S

Personality Type	Parameter	1	2	3	4	5	6	7	8	9	10
S	Mean	9.32	5.91	6.14	10.00	10.00	9.77	7.59	5.45	7.68	8.18
	SD	1.58	3.18	2.14	0.00	0.00	0.42	1.40	1.67	0.97	1.27
N	Mean	9.20	7.00	5.50	10.00	10.00	9.70	7.80	5.60	7.90	8.50
	SD	1.17	3.87	1.80	0.00	0.00	0.46	1.33	2.15	0.83	1.43

(S = Sensing, N=Intuitive, SD = standard deviation, Units of all parameters in categories 1-10)

The results from above show that Sensing people were better at processing time and operator performance level while Intuitive people had a better stack quality. Both types showed a high standard deviation value on processing time. The Intuitive personality type had a faster processing time but with such high standard deviation, it is hard to summarise whether this is true in reality. To further analyse a histogram of overall performance scores was created (Figure 6).

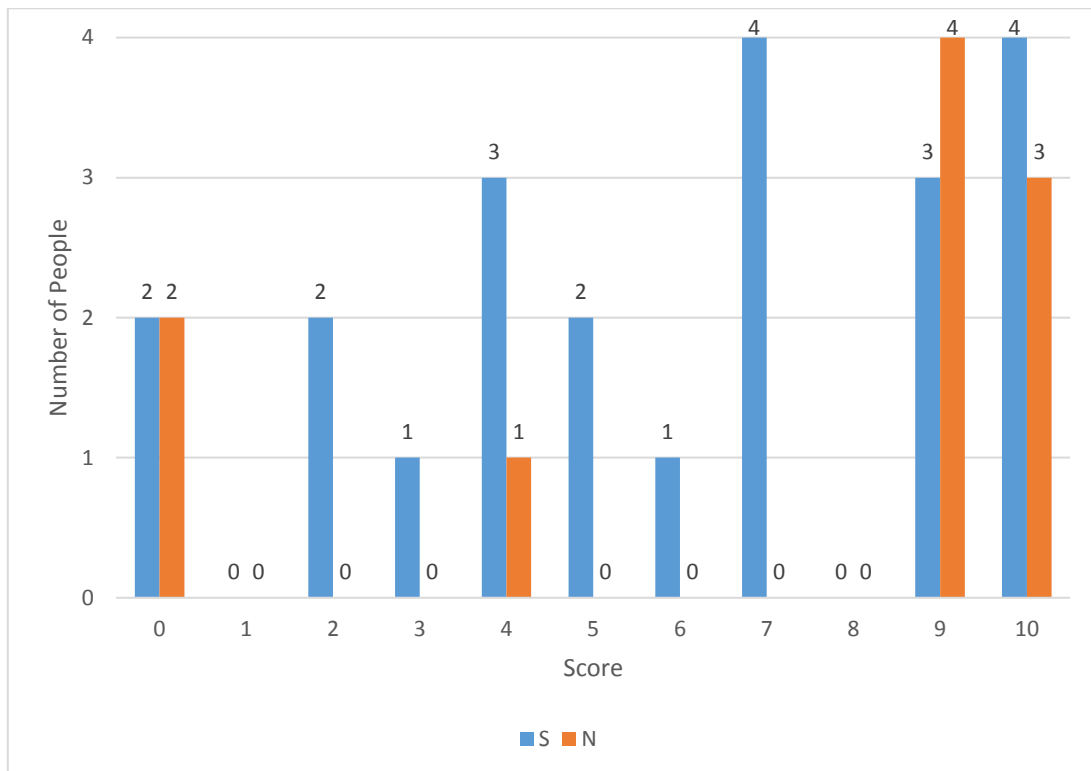


Figure 6: Scoring details for parameter 2 (Process Time), S=Sensing, N= Intuitive

Figure 6 above shows that N and S have the same number of people with a score equal to or higher than 8. However, there was a significant number of volunteers of type S, who passed the test with an acceptable score, which is equal or higher than 5. The scoring trend for type N did not have many in the middle class, the majority of the population scored a high score, while some scored 0 or 4 points. Overall, the type S was decided to be the favoured type for the processing time parameter as they tended to have a more reliable performance outcome.

Thinking vs. Feeling

There were 10 volunteers with the Thinking type of personality and 22 with the Feeling type. This indicated that most of the participants were more likely to make decisions by following their hearts. The overall score analysis is shown in the Table 7 below.

Table 7: Result analysis for personality type T & F

Personality Type	Parameter	1	2	3	4	5	6	7	8	9	10
T	Mean	9.40	7.00	6.50	10.00	10.00	9.80	7.90	6.90	8.20	8.80
	SD	1.02	3.19	1.43	0.00	0.00	0.40	1.30	1.30	0.60	1.08
F	Mean	9.23	5.91	5.68	10.00	10.00	9.73	7.55	4.86	7.55	8.05
	SD	1.62	3.50	2.24	0.00	0.00	0.45	1.41	1.69	0.99	1.36

(T=Thinking, F= Feeling, SD= standard deviation, Units of all parameters in categories 1-10)

The results data above showed that people with a Thinking (T) personality type had a higher mean score in all parameters, excluding the two pass/fail parameters which were saw damage (4) and machine damage (5). The parameters which Thinking people were better at than Feeling people

were processing time, stack quality, stump height, boom usage, simultaneous boom movement, operator skill level and operator performance level. The data suggests that in general a person with a Thinking personality can perform better, but with the relatively similar means of the scores, this conclusion is not absolute.

Perceiving vs. Judging

The number of volunteers with Perceiving and Judging personalities was equal, with 16 of each, which should have provided the fairest comparison between the four fields. The most critical parameters should have come from parameters 9 (Operator skill level) & 10 (Operator performance) as they reflect more about the strategic planning and way of approaching the overall task. The overall score analysis of these volunteers is shown in Table 8 below.

Table 8: Result analysis for personality type P & J

Personality Type	Parameter	1	2	3	4	5	6	7	8	9	10
P	Mean	9.31	7.06	5.81	10.00	10.00	9.81	8.00	5.81	7.88	8.31
	SD	1.16	3.31	1.67	0.00	0.00	0.39	1.12	2.19	0.70	1.31
J	Mean	9.25	5.44	6.06	10.00	10.00	9.69	7.31	5.19	7.63	8.25
	SD	1.71	3.39	2.38	0.00	0.00	0.46	1.53	1.33	1.11	1.35

(P= Perceiving, J= Judging, SD= standard deviation, Units of all parameters in categories 1-10)

The biggest performance difference came from the processing time (parameter 2), where people with a Perceiving personality showed a higher average score and both groups had a high standard deviation. Perceiving people also had better performance in parameters like boom usage (7) and simultaneous boom movement (8). Unlike the prediction made above, people with Judging personality had a slightly lower average score for parameters 9 and 10, however they were hypothesised to be the group with better organized felling plans.

The next part of the data analysis investigated the three best performers from each personality field (Volunteers A, B and C). They were seen as the person who makes the best use of their personality type. They were asked to return and retake the simulator test.

Figure 7 shows the results of Volunteer A from both attempts. Volunteer A held the highest scores in the personality field ISFJ. The total scores were the same for Volunteer A from both attempts, but the performances indicated that they got better on the operating skills (9) and gave some consideration on safety and the fluency of their operation which is a result of better understanding of the project and awareness of the case in real life operations. This included a higher level of simultaneous boom movement (8) and smoother boom speed. The decrease was noted in slower processing time and lower stack quality.

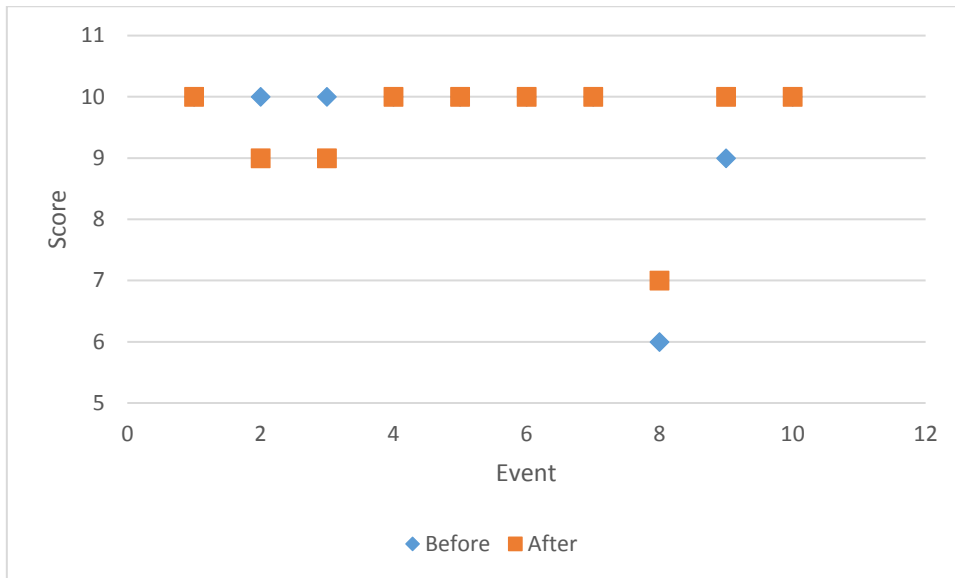


Figure 7: Score data for Volunteer A, Before is the first attempt, After is the return attempt.

The next best performer was Volunteer B, who had the highest overall scores of participants with EN personality fields. The figure below showed Volunteer B had a great improvement on their stack quality as they had more concerns about how to lay out the logs in the felling plan and followed it well. The faster speed came from a higher confidence on operating the system; as they pushes the joysticks further and faster than before. However, there were decreases on simultaneous boom movement and boom usage, which showed they were less familiar with the machine since the first test.

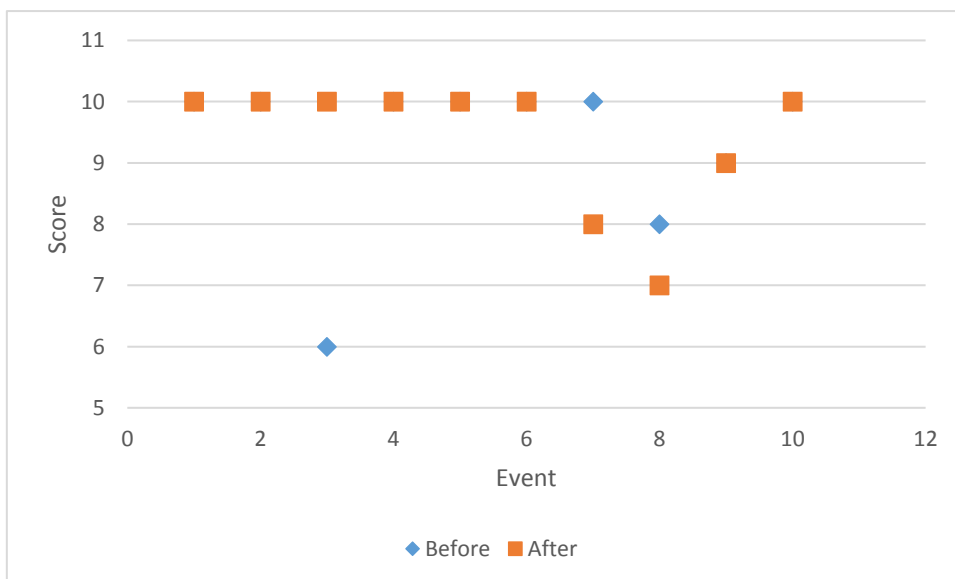


Figure 8: Score data for Volunteer B, Before is the first attempt, After is the return attempt.

The final best performer (Volunteer C) had the highest scores in fields TP. Their two attempts scores were plotted in Figure 9 below, but were not showing similar patterns. From the data Volunteer C got faster on felling the trees and slightly slower on processing the trees. And was the most inconsistent best performer out of these three people. They had some improvements in parameters including stack quality and stump height control, but a significant decrease in the

simultaneous boom movement score and slight decreases in boom usage and operator performance.

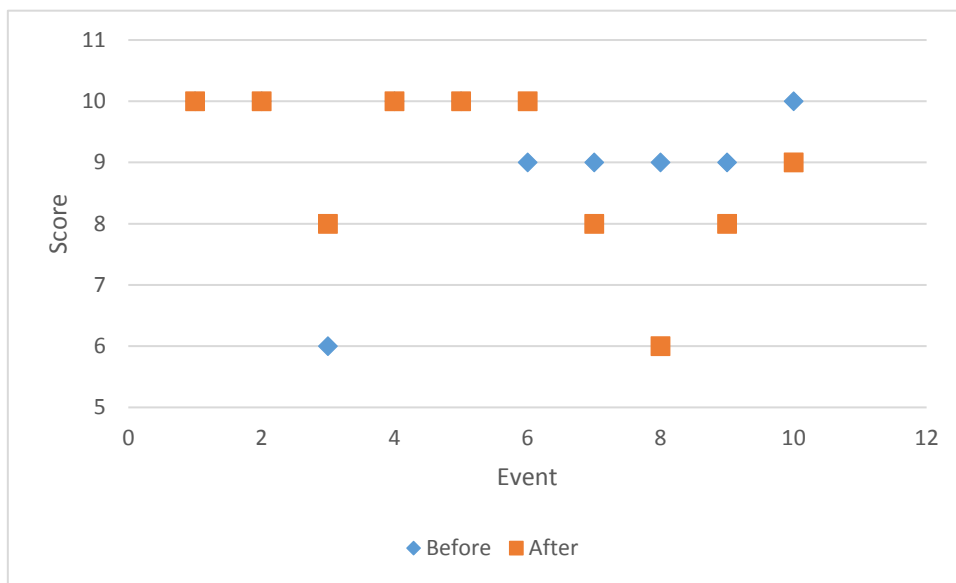


Figure 9: Score data for Volunteer C, Before is the first attempt, After is the return attempt.

From the **energy** field to review their performances, Volunteer A (Introvert) was acting more like a listener, kept gaining information and details from the supervisor rather than asking the questions them self, they gained motivation and a higher job satisfaction by doing these tasks alone, and they didn't lose interest over time. On the other hand, Volunteer B (Extravert) was more active on asking the questions, discussed some ideas with the supervisor, more active on trying new plans which were not necessarily covered in the operating tutorial. However, they lost interest over time and needed to be satisfied by finding new challenges to keep working.

From the **mind** field, Volunteer A (Sensitive) made good use of the practice session and was more practical than trying to memorise the functions of each button. They also planned on focusing to polish the weakness by making more practice attempts. Volunteer B (Intuitive) was a faster learner than Volunteer A on getting familiar with the machine. They made good use of the instruction handout and memorized the functions of each button.

The next two personality fields are **nature** and **tactics** with two best performers' Volunteer A (Feeling and Judging) and C (Thinking and Prospecting). It was assumed that within nature personality thinking would outperform Feeling. However this didn't happen as Volunteer C showed high inconsistency in the second attempt majorly due to the loss of interest. They were a very fast learner and were high-level skilled operator, they followed the felling plan and used skills to ensure a high passing rate for the test.

The last personality field that this study looks investigated was tactics, which was best reflected by the operator's felling strategy and plan. Volunteer A (Judging) showed a more mature and larger range of considerations in their felling plan, which included both safety concerns and operation fluency where most of the other volunteers only focused on how to pass the test. Volunteer A was more organized on the felling plan details than Volunteer C (Prospective) showed a higher creativity potential and flexibility.

DISCUSSION

It is believed that there is no perfect personality combination that will guarantee the best performance for all harvesting operations. However, with the data analysis demonstrated above, it is accepted there could be a favoured type for some specific tasks. The two major fields that have the most impact on performance were energy and nature.

It is possible for operations managers to improve the current working environment by paying more attention to personalities of their team members. For example, this could be achieved by events such as creating a better harvest plan to enlarge the amount of time the fellers spend alone and minimise the interactions of them with other members in the crew if the operator has an introvert personality type. In contrast, when teamwork is necessary, the managers could set up training to help the operator to learn how to do teamwork and create some plans to make a closer team connection. On the other hand, if the current operator is an extravert, the managers should do plans which will increase the quality of their working experience.

The second critical personality field is nature, which includes thinking and feeling. As mentioned above, the thinking people stick to the plans very closely and make decisions over the priorities of the companies; this adds more pressure on the quality of the current harvesting plan. It is beneficial for the operator to follow the heart feelings only if they are an expert on the job, and these decisions should be applied after a discussion with the managers.

Limitations and Future Improvements

1. Population size

As mentioned before, there have not been many studies about soft skills in forest machinery operations. According to the required population size equation, the more people participating in this study, the more reliable the result. Just like the Myers' personality trials, it was intended to be matured with an on-going data collection, and the conclusions from this initial study would lead in the direction of the potential impact that personality could have on the felling machine operation.

2. Task difficulty

The designed test was simplified for the volunteers as they were not professional operators. This also minimised the difference in learning ability between different personalities and ways of solving complex tasks. The flat terrain in the testing program would benefit the personality type which fells trees faster but is less careful about their movements. These volunteers should be tested on different terrain and piece size, as that will show more about how they will deal with the environmental constraints and other tasks which require a higher level of operation.

3. The personality test result

The personality test is believed to be highly reliable, but the result comes from the favoured side for each field. This is complex when someone scores near the middle; it is not fair to say that person is that type of personality compares with someone scores near 100% for that field.

4. Project outcomes and future focus

This project is looking for a better management outcome on staffing efficiency, the results were showing that personality has an impact on the operational performance. In the future, the focus should be more on the operational safety concerns. Volunteer A in the return attempt bought up the

idea of safety concern, different personalities may have different ideas and definitions of hazards. A more complete safety plan could be achieved by surveying people with different personalities.

5. The scoring form

The ten categories in the scoring form were defined as equally weighted, in reality, there were ones that were more important than others. There should be more studies to give a more appropriate weight on each parameter. Parameters like saw damage and machine damage were critical for this study, the future studies should change them into not just pass-fail parameters, with a scoring method behind based on the performances.

CONCLUSION

Personality was found to be a factor which could impact on the operator's performance, but it should only be used as an assistance tool while judging the operator's performance. It is possible to use personality focused training and change of management plans to lower the effect or increase the benefits which personality could bring to the harvesting operation. It should be used as a tool to help the management team to have a better understanding of their team members, and use it for more focused training which improves the potential weakness the operator have with their specific type of personality. The soft skills of felling machine operators are important to consider while making management decisions, but hard skills should still be the first priority for the company for productive purposes. It is more important to use soft skills to assist in making hiring decisions than judging the current felling operators work. The best personality type that is recommended by this study on a normal ground-based operation is ISFP, and the best personality type for a site with more constraints is ISTJ.

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APPENDIX 1: Scoring Categories

An example of the scoring form that has been used to record volunteer's experiment data:

Section Title	Factor #	Parameter	Score	Comments
Time	1	Felling Time		
	2	Process Time		
Operating Performance	3	Stack Quality		
	4	Saw Damage		
	5	Machine Damage		
	6	Stump Height		
	7	Boom Usage		
Operator Performance	8	Simutaneous Boom Movement		
	9	Operator Skill Level		
	10	Operator Performance Level		

Figure 10: Experiment scoring form

Scoring Calculation Declaration: There were maximum 10 points for each parameter to score according to these scoring rules.

Parameter 1: Felling Time

Table 9: Marking schedule for Parameter 1

Time (s)	Scores
<35	10
36-40	9
41-45	8
46-50	7
51-55	6
56-60	5
61-65	4
66-70	3
71-75	2
76-80	1
80+	0

The class data from FORE205 gave an average of felling time of 59.02s, and then according to the average time, the middle score is set to be 60s, with 5 seconds as the step size between each point.

Parameter 2: Processing Time

Table 10: Marking schedule for Parameter 2

Time (s)	Scores
<10	10
11	9
12	8
13	7
14	6
15	5
16	4
17	3
18	2
19	1
20+	0

The time taken by the operator to bring the tree down to the ground after cutting, and bring the stem to the planned area to process was 10 seconds (result of testing the supervisor and team members), but it depends heavily on the felling strategy. It is. The time to scan the stem and cut it into required log grades was the same for each operator, the processing time was recorded just before the operator started to feed the machine.

Parameter 3: Stack Quality

Table 11: Marking schedule for Parameter 3

Score	Log Grade	Score	Lay-out
5	1 pile for pulp, 1 for saw log. 2 piles are nearby	5	Logs are parallel and close to each other
4	1 pile for pulp, 1 for saw log. 2 piles are far apart	4	Small gaps between logs in each pile
3	1 big pile, saw log on one side, pulp on the other	3	Larger gap but < 30*
2	1 big pile, logs from each tree are together regardless to the grades	2	Larger gap <45*
1	1 big piles with not much arrangement	1	Large gap <90*
0	Random placing	0	Random laying

The stack quality had a significant impact on the work efficiency of forwarder, so it is important to work as a team and make other people's job easier if applicable.

Parameter 4: Saw Damage

The John-Deere built-in program recorded the operator's saw damage attempts during the operation. This could occur either due to holding the tree on an angle or processing the stem too low close to the ground. This is a health and safety concern, and a financial concern. The operator should make sure there is no unnecessary saw damage, this will slow down wear and tear of equipment.

Parameter 5: Machine Damage

The John-Deere built-in program recorded the potential machine damage during the operation. This is similar to Parameter 4, machine damage is more expensive to fix and more dangerous for the operator. This reflects the operator's skill level and the quality of the felling plan.

Parameter 6: Stump Height

Table 12: Marking schedule for Parameter 6

0-20 cm	10 points
21-30 cm	1 – 9 points
30+ cm	0 points

These values were set up by the built-in program, which is a good practice for stump height control. The 20cm stump height allows enough space for the saw to operate without cutting into the ground, the extra 10 cm set the acceptable range for a small value loss. Anything higher than 30cm, the loss of value would be too significant especially as the bottom log is high quality wood. The built-in flat terrain made the task easier for these unprofessional operators, these built-in values of stump height are believed to be effective for this study.

Parameter 7: Boom Usage

The supervisor observed the number of mistakes the operator has made during the test on the boom joystick, combine it with the overall visually performance to give a fair scores. (1 mistake takes away 1 point)

Parameter 8: Simultaneous Movement

As these lab volunteers were not professional felling machine operators, it is difficult to judge their performance with the professional simultaneous standard. Therefore, the scores for each operator were given according to the program's simultaneous scores.

Table 13: Marking schedule for Parameter 8

Simultaneous Movement Score	Points
1.95+	10
1.85-1.94	9
1.75-1.84	8
1.65-1.74	7
1.55-1.64	6
1.45-1.54	5
1.35-1.44	4
1.25-1.34	3
1.15-1.24	2
1.05-1.14	1
0-1.04	0

Parameter 9: Operator Skill Level

The supervisor gave the scores based on how familiar the operator is with the machine, how many mistakes had been made during the test, how the speed of movement and consistency of the operator's performance was, the simultaneous score of the operator and how well the operator was on following the work plan that had been made before the test.

Parameter 10: Operator Performance Level

The supervisor gave the scores based on how confident the operator was on the movement, how well they could explain their work plans to the supervisor before the test, and the overall operating habits.

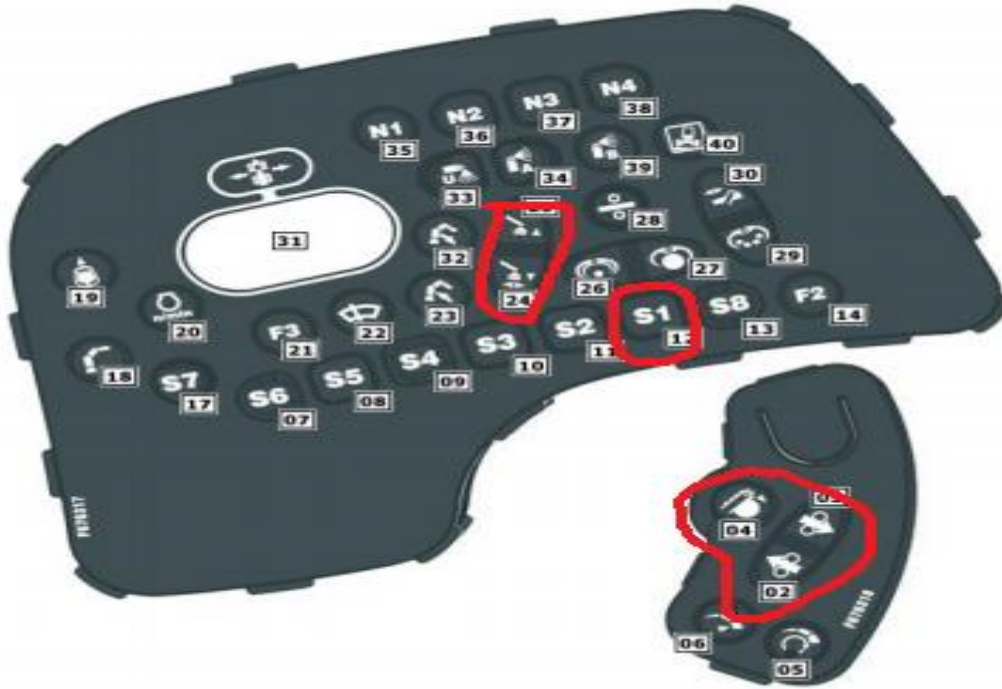


Figure 11: Left controlling pad of the simulator

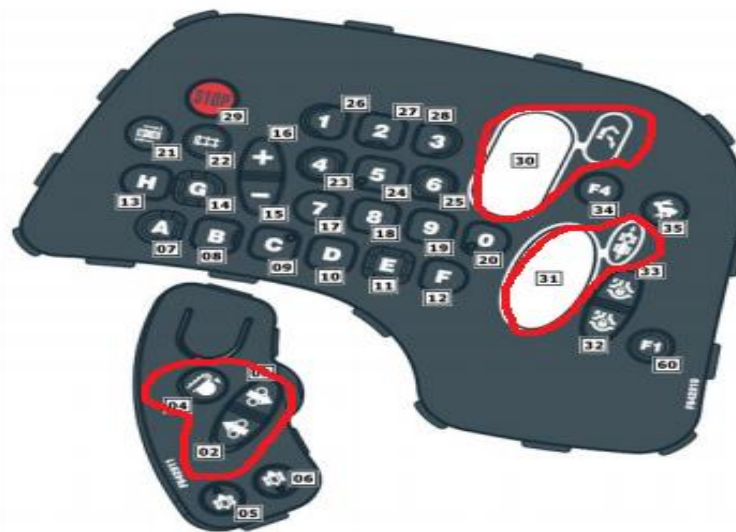


Figure 12: Right controlling pad of the simulator

APPENDIX 2: Raw Data from Simulator Trials

		Fell			Process		
	Subject (code)	T1 (s)	T2 (s)	Average	T1 (s)	T2 (s)	Average
1	GH	28.0	40.0	34.0	14.0	12.0	13.0
2	SG	50.0	32.0	41.0	26.0	27.0	26.5
3	AA	16.6	21.1	18.8	7.3	9.5	8.4
4	NM	24.9	32.5	28.7	10.8	11.5	11.1
5	LZ	21.0	29.0	25.0	13.0	20.0	16.5
6	KE	16.6	24.9	20.7	8.4	12.0	10.2
7	EK	28.2	22.7	25.4	7.7	7.8	7.8
8	FL	53.0	70.0	61.5	12.0	20.0	16.0
9	AV	19.0	27.0	23.0	12.0	10.0	11.0
10	TP	23.4	16.7	20.1	11.0	9.0	10.0
11	JK	30.0	21.0	25.5	21.0	35.0	28.0
12	CK	42.8	33.0	37.9	14.0	14.5	14.3
13	SC	17.6	25.0	21.3	26.0	30.0	28.0
14	AUC	20.7	28.3	24.5	13.4	14.1	13.7
15	JT	54.0	53.0	53.5	11.0	12.0	11.5
16	LL	21.0	27.0	24.0	13.0	14.0	13.5
17	QL	35.0	35.2	35.1	10.6	9.9	10.3
18	VG	32.0	30.0	31.0	18.0	19.0	18.5
19	MJ	17.1	10.0	13.6	7.0	10.0	8.5
20	WW	32.0	33.0	32.5	10.0	15.0	12.5
21	PH	40.0	41.0	40.5	8.0	6.0	7.0
22	JJ	42.7	27.0	34.8	28.1	21.7	24.9
23	TB	11.4	32.6	22.0	17.6	17.1	17.3
24	PD	27.6	20.9	24.2	14.3	16.3	15.3
25	SV	16.0	22.0	19.0	9.0	8.0	8.5
26	VA	18.0	20.0	19.0	8.0	10.0	9.0
27	MM	16.0	24.0	20.0	14.0	16.0	15.0
28	ZY	10.7	47.0	28.8	11.9	10.0	11.0
29	MI	25.0	38.0	31.5	23.0	17.0	20.0
30	BC	15.4	16.3	15.8	9.0	12.0	10.5
31	VC	30.0	42.0	36.0	15.0	17.6	16.3
32	DT	38.0	44.0	41.0	14.0	21.0	17.5
			Felling Average	29.1		Processing Average	14.4
			SD	10.5		SD	5.7
			SE	1.9		SE	1.0