HARVESTING TECHNICAL NOTE

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Beneficial Work Practices Framework for Loading Operations

Summary

Driven by mechanisation, traditional career pathways in forestry crews are evolving. The Workforce Skills & Development Project aims to reshape these pathways to empower operators in their learning process, bolstering mental well-being and diminishing the learning curve. Video-based feedback can help improve operator performance by offering specific, timely, and content-rich instruction. Using video, experienced loader operators were reflectively interviewed to identify beneficial work practices in various loading processes. The importance of operator skill in enhancing productivity, safety, and overall efficiency of skid site activities is highlighted by the framework, as is the need for efficient, controlled machine movements. A performance framework for log loading operations was generated for application in video-based self-directed learning.

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Background

The FGR project Workforce Skills & Development is undertaken as part of the Human Factors component of the Primary Growth Partnership (PGP) programme, 'Te Mahi Ngahere i te Ao Hurihuri – Forestry Work in the Modern Age' (FGR, 2018). The objective is to identify the skills, training requirements, and new roles in forest operations due to the new automated machines and technologies developed in this Programme. This knowledge will guide the design of new training resources and technologies to improve worker learning experiences, while maintaining safety and productivity on-the-job (FGR, 2019). Scion's Human Factors group leads this work and engages specialist expertise when appropriate.

Introduction

Despite the capabilities of modern logging machines, they are still highly dependent on the skills of the operator for achieving the gains in productivity and safety they promise. Operator skill has been shown to be a contributing factor to machine downtime, repairs and maintenance costs and the consistent flow of wood required to ensure the rest of the crew are productive (Kirk, Byers, Parker, & Sullman, 1997). Through the impact those skills have on the potential for the operator experiencing 'flow' (Demerouti & Fullagar, 2013) and their social status (Best, 2022), those skills are also fundamental to operator wellbeing. Experienced operators report that these skills are largely learnt on the job and take some time to develop (Best, 2022). That experience cannot be easily replaced by traditional 'off-job' training approaches (Vahdatikhaki, Langroodi, Scholtenhuis, & Dorée, 2022) where it is difficult to replicate the task and environmental constraints that interact with the operator's motor skills to determine performance (Renshaw, Chow, Davids, & Hammond, 2010). There is a lot to be gained, therefore, in being able to reduce the 'on the job' learning curve for developing machine operators.

One element of the training process that can enhance learning is feedback. Feedback that is content-rich, specific to the task being performed and timely can prevent the embedding of unhelpful habits, enhance the acquisition of beneficial psychomotor skills, and improve motivation to learn (Vahdatikhaki *et al.*, 2022). However, Vahdatikhaki *et al.* (2022) also point to several difficulties that arise when a trainer is trying to give that feedback within an operational environment:

1. Timing – instantaneous feedback risks breaking the trainee's concentration and disturbing the workflow, while delayed feedback requires the trainee to recall what they were doing during the event the instructor is referencing;
2. Perspective – the instructor is observing from outside the cab, the trainee is working inside the cab and that difference in perspective may lead to differences in interpretation and miscommunication; and
3. Proximity – the instructor needs to stand a safe distance away from the operation which increases the chances of the instructor missing some of the performance details.

Video-based feedback has the potential to overcome these difficulties by either eliminating the need for an instructor in generating the feedback or by putting the instructor and the trainee side-by-side during the feedback process. Both supervised and unsupervised video feedback has been shown to improve

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performance in suturing by trainee surgeons over and above the standard lecture-based feedback (Nesbitt, Phillips, Searle, & Stansby, 2015).

The objective of this project is to explore the potential of video-based feedback to improve loading operator performance. The previous research noted above suggests that video-based feedback could enhance the learning process and thus help to reduce the loading operators learning curve.

Loading operators have been chosen because loading is typically the starting position for new entrants in a fully mechanised harvesting crew. To enable unsupervised feedback will require developing a performance framework for loading operations based on work practices used by expert loader operators to enhance productivity and safety, while minimising wear and tear on equipment. That framework can be used alongside an 'off-the-shelf' sports video analysis platform by either an instructor or the trainee operator to assess the trainee's work practices and generate guidance on potential improvements. This report covers the first stage of that process: developing the performance framework by identifying the beneficial work practices used by experienced loading operators.

Research Methods

Participants

The participants consisted of eleven excavator-based loader operators located across three regions (Otago, Nelson, Bay of Plenty). All were selected using an assessment of their expertise by either their employer or the harvesting manager of the forest company they worked for. They worked in crews that used a variety of prime mover configurations: skidder, forwarder, and hauler.

Data Collection

Semi-structured interview was used to collect data that identified work practice solutions likely to be faced in a loading operation (Renshaw et al., 2010). Rather than rely on memory, the participants were asked to watch a video of an experienced loader operator performing some of the key tasks of loading – fleeting and stacking from the processor output pile and loading trucks. The video consisted of both external and in-cab perspectives. While watching the video, the participants identified the work practices that they thought enhanced the productivity, safety and quality of the video subject's loading operations. Prompts were used to ensure that not only was the work practice identified but also the environmental conditions that were interacting with those work practices (e.g., skid layout, location of the processors chain shot zone) and the consequences of those on the video subject's performance. As suggested by Corbin and Strauss (2015), the questions and prompts were based on the conditions – action / interaction – consequences framework. Thus, the themes captured could be considered the information-movement couplings that make up the beneficial work practices performance framework (Renshaw et al., 2010).

Figure 1. Loader operator in-cab video view.

Analysis

The interviews were transcribed and then template analysis (King & Brooks, 2017) used to break the transcripts down into codes (a label applied to represent a consistent meaning across a number of references from the transcripts - Birks & Mills, 2015). The codes could then be clustered into themes which could be considered beneficial work practices. An initial list of themes was developed from preliminary coding and clustering of a sub-set of the interviews (the first four). This template was then used to code the remaining transcripts and as new themes were identified they were added to the template. The completed template was then used to code the full set of responses. The final set of themes in the template were the beneficial work practices that made up the performance framework.

Template analysis (King & Brooks, 2017) was selected as the analysis method because it satisfied several needs for the project. Firstly, given the nature of the data collected, the template and its constituent themes would provide the required output for the study. Secondly, using an established framework as the basis for the analysis was considered faster than other forms of thematic analysis and made it clearer when there was sufficient data to support the themes / beneficial work practices. Finally, it is a well-structured and documented process that provides an audit trail for analysis decisions and the means of engaging other researchers. The coding of the subset of transcripts used to set up the template was reviewed by a colleague to ensure the beneficial practices identified by participants from the video were adequately captured in the template.

Results

Roles and Processes

While fleeting, stacking and loading are the primary operational processes carried out by the loader operator, it was clear the more experienced operators saw themselves as central to the functioning of the skid. Comments like *"you're there to run the skid"* (Participant 6 - P6) and *"you're quite often looking after everybody because you're sort of the heart of the operation"* (P5) suggested the loader operator's roles

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went beyond the operational processes they undertook with their machine. Alongside the work assigned to the machine they operated, participants referred to the assigned communications role (maintain communications with crew, drivers, and visitors) and the overlapping responsibility of keeping skid users safe. These roles were identified by participants as having higher priority than the loading and fleeting role.

Figure 2. Single loader skid.

Being at the centre of an effective communications system was essential for the work of the loader operator and the crew. P1 commented that *"a good loader operator is someone who facilitates the work of all the other members of the crew"*. A role centred on their ability to communicate, particularly where the operational needs of other crew members interacted with the skid organisation.

Overlapping the communication role was a responsibility to keep other skid users safe from the risks presented by both loading and processing operations. These are the risks of being struck by a moving grapple, a moving machine or chain shot from the processor. While some of this risk could be managed through the skid layout (demarcating zones for safety and chain shot), oversight of the plan sat with the loader operator and needed to be recognised when considering what is an effective performance by the loader operator.

The objective of the role that was of most interest in this study – loading and fleeting – was efficiency for both the loading of the trucks with in-spec logs and the use of skid space. Achieving that objective involved five processes (in order of the priority assigned by the participants):

1. Setting out the skid: set out the skid to minimise the amount of loader movement (slewing and walking) required to fleet logs away from the processor pile and load trucks.
2. Fleeting from processor: moving wood away from the processor's cut pile into stacks while minimising interference with the processor's operating and facilitating efficient truck loading.
3. Ordering trucks: ensuring, as much as possible, that the loads uplifted matched the available log stocks and log production.
4. Loading trucks: loading trucks as quickly and safely as possible so that the logs are square and tight within the bolsters (every log on the load has the maximum contact with the chains, bolsters or other logs that are in contact with the chains and / or bolsters) and flush for scaling (if required).
5. Keeping the load out strip tidy: ensuring the load out strip remains accessible for trucks.

These processes are interconnected. The effectiveness of each process is highly dependent on the preceding process. Beneficial work practices have been identified for each process that ensure the effectiveness of both that process and the subsequent process.

Beneficial Work Practices

Beneficial work practices are those practices participants considered helped them to load the logging truck to the maximum allowable weight safely and quickly, with efficient use of the skid and less risk of harm to others and damage to logs and trucks. The practices presented in Tables 1-5 are those that attracted agreement amongst the participants either as a practice identified as helpful or not unhelpful.

The beneficial work practices for the process of setting out the skid are presented in Table 1. Where the stacks were located relative to the processor cut pile and the load out strip dictated how much work was required to fleet wood away from the processor. Given the number of log grades and lengths' each participant was trying to accommodate on their skids meant walking the machine was inevitable. Walking was considered a practice that reduced machine productivity and increased wear and tear. That was evident in the participants ideal skid layout where the need to minimise walking while keeping the loaders tracks off the load out strip and the truck protected from chain shot seemed to produce similar layouts.

Table 1: Beneficial Work Practices – *Setting out the skid.*

Work Practice	Benefit
Place most common logs stacked on the end of the stacks closest to the processor pile	Reduce fleeting movements of loader from cut pile to stack
	Speed up loading by enabling quarter turn loading from most common log stack
Place least common log grades farthest from processor pile	Reduce fleeting movements of loader from cut pile to stack
Eliminate need for loader to cross load out strip by placing any crossing point behind the load out strip.	Minimise damage to load out strip
Coordinate stacks and loading position to place a chain shot barrier between the processor and trucks	Eliminate risk of truck cab or driver being struck by chain shot

Fleeting from the processor was considered the next priority (beneficial work practices presented in Table 2.) The subject operator attracted compliments from the participants on the quality of the stacks they had constructed. That's because *"… a big part of it is the tidier your stacks are … the easier and the quicker your loading"* (P5). Having a stack that was already flush and was shaped to make it easier to build full grabs and provide access to the older logs minimised the number of grabs required to load the truck or trailer, keep the age of the wood down in the stacks and reduced the amount of work required once the load was on the truck to make it presentable for scaling.

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The participants were also aware that how they fleeted away from the processor had an impact on the processor's productivity. They had worked out ways of ensuring they were not trying to grab logs from the cut pile in a way that would interfere with the processor either by being in front of the processors slew direction or by letting wood pile up and interfere with the processors ideal operating height. Finally, the subject operator's habit of walking the logs between the processor cut pile and the first stack generated the most comment. *"See how it's just walking back and forward there? I would swing my whole heap out"* (P10). The participants considered the use of loader's full boom extension to be quicker and less machine wear. *"I would rather have wear and tear on my boom than my tracks … tracks are harder to maintain than those by a long shot"* (P8).

Table 2: Beneficial Work Practices – *Fleeting from the processor*

Work Practice	Benefit
Fleet from behind the processors slewing direction	Minimise interference with processor
Maintain processor cut pile stacks at a low consistent height	Ensure processor can slew at one accessible height
If operator is doing QC, check grade of logs when they are in the grapple	Faster than laying logs out
Use the boom's reach to move logs, not the tracks	Faster fleeting
	Less track wear and tear
	Less damage to the skid surface
Stack logs the same way they will be loaded on the truck	Easier to load if logs are already flush and / or centralised
Set a wide base on the stacks and build up the pyramid from there. Keep track of log age by spraying the felling date on an outside log.	Exposes the bottom logs on the stack to prevent older logs getting stuck at the bottom.
Stack the large end to the front of the stack.	Easier load planning when loading.
Dot the large end's sitting in the stack.	Safer. Don't have to climb up on the truck.

What practices were beneficial for ordering trucks (see Table 3) was something that only came up as an indirect outcome of the subject video. Evidence of the practices that helped or hindered getting truck loads uplifted that matched what was being cut and the levels of stock held on the skid came from prompts about what had to be communicated to who and P7's description of the interaction they had with despatch through their electronic data transfer system. The importance of despatch knowing the stocks was also evident in what happened when the loads uplifted did not match what the bush was cutting and storage was getting tight: *"we get a certain amount of grades and how many loads we can pack out in a week, so we plan for that … so that goes to the processor and he knows what to cut … by Wednesday, Thursday [we know] how much more we need or we don't need [and we] cut something else we need"* (P9).

Table 3: Beneficial Work Practices – *Ordering trucks*

Work Practice	Benefit
Keep track of stocks and tell despatch	Helps despatch to allocate trucks

The beneficial practices for loading trucks are presented in Table 4. As this was the main subject of the interview video, the evidence from the participants is focused on the practices the subject operator was using that both helped and did not help achieve the sought-after outcomes of this process. What helped, in terms of the trustworthiness of the data, was that the subject operator was forced into using some unhelpful practices due to the prevailing skid conditions that could have only been changed during skid set up and fleeting. For example, the load out strip was not protected from the risk of chain shot from the log processor which restricted where the truck could be positioned. That forced the operator to load from a position that required sub-optimal practices, such as slewing the boom side to the truck and sitting slightly forward of the back of the truck's bunk (not in line with the flush line). Also helpful in getting a complete picture of the beneficial practices was the different perspectives of the lesser experienced operators. These operators were more focused on safety - what contributed to a safe load and what reduced the risk of harm to other skid users.

Figure 3. Truck loading.

Table 4: Beneficial Work Practices – *Loading trucks.*

Work Practice	Benefit
Unload trailer sitting in a position where the ring feeder, drawbar and driver are visible	Reduces risk of harm to truck, trailer, and driver
If the truck scales can be read inside the cab, move the truck rather than the loader. If the truck scales are read underneath the deck, move the loader rather than the truck.	Reducing avoidable wear and tear on tracks.
Position loader in line with end of the bunk to load flush.	Speeds up scaling at port
	Flush logs look better on the trailer
In moving from the stack to the truck, slew away from the truck cab and door side to the truck/ trailer.	Reduce risk of damage to truck cab (particularly if the driver is in it).
	Maintain visibility across the truck / trailer.
Centre the grapple on the grab	Reduce risk of logs sliding out
	Easier placing logs in the bunk
Work / roll the grapple, beak first, into the top / middle of the stack, making sure the grab is tightly packed and the beak and tynes on the grapple are touching or are anchored on the bottom 1/3rd of the bottom log before lifting. Make the effort to get the biggest grab the grapple can safely handle.	Faster loading
	Reduced risk of log damage
	Reduced risk of crossed up logs making placing them easier
	Reduced risk of a log slipping out of grab when lifted.
Load logs centred between the bolsters	Improved chance of even weight distribution
	Easier to offload, particularly for a front-end loader
Load truck / trailer from the far side bolster to the near side bolster. If there is the visibility, load up bolsters first and create a trough in the middle to roll logs into.	Ensures good contact between logs and far side bolster before it is blind to the operator
Place the bottom log in the grab into position on the truck / trailer and roll the other logs out of the grapple and into place. If there is the visibility, push down on the bottom log as it is released and let the logs spread out to the bolsters under a bit of pressure.	Logs tighter in the bunk
	Faster loading because less re-arranging of logs is required.
Keep the bunk square by building up levelled off layers of logs with "top and tailed" large ends and small ends that follow some sort of pattern which is obvious to scaling staff, e.g., swap large ends and small ends halfway through the bunk or layer by layer.	Logs tighter in the bunk
	Better weight distribution
	Easier to scale
Tap / flush up logs with the side of the grapple in small sections of the load	Less force required to move logs if less weight sitting on top of them. Less risk of damage to the logs or truck.
	Flush logs are easier to scale and look better on the truck.
Use downward pressure on grapple to punch logs into place	Logs tighter in the bunk
Build up crown using smaller grabs (one or two logs)	Less re-arranging of logs

For the more experienced operators the focus on safety was a given, so they appeared to be more focused on how to achieve a safe load quickly. The beneficial practices for truck loading are, therefore, a mix of some basic practices (e.g., making sure the load is centred within the bolsters is a considered a

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minimum standard within the LTSC guidelines for truck loading) and the practices that will help the operator do things more quickly (e.g., working the grapple to get the maximum grab).

Because the discussion centred around the practices used by the subject operator in the video there was some potential for important practices that were not used in that video to have not been discussed in the interview. There was an attempt to minimise this risk by asking the question "What have you not seen that you think might be important?"

The practice of "pencilling" came up with some of the participants. "Pencilling" is the practise of standing the grab on its end to flush up the logs before placing them on the truck or trailer. It was left out of the list of beneficial practices because it is an extra step in the loading process, and it can be argued that the necessity is a function of poorly flushed stacks. However, the greatest need for pencilling appeared to be associated with short log lengths (e.g., 3.7m lengths) which, because they only just overhang outside the bolsters, are difficult to flush up by tapping with the grapple. "Pencilling", therefore, may well be considered by some operators as an essential practice depending on the log lengths they are loading. If it is used extensively, however, it will slow the loading process.

Finally, within the subject video the operator can be seen helping a truck back into position by using the grapple to put some weight on the truck's drive wheels. That incident provoked some discussion on how it could be avoided. That came down to two practices: keeping the loader's tracks off the load out strip, something that is best prevented through the skid layout, and using something (a blade, bucket, or log) to brush away mud and bark as it builds up on the strip. This last practice makes up the beneficial work practice presented in Table 5 for keeping the load out strip tidy for trucks.

Table 5: Beneficial Work Practices – *keeping load out strip tidy for trucks.*

Work Practice	Benefit
Scrape off loading strip regularly with a log / blade / bucket.	Maintain accessibility of load out strip for trucks.

Discussion

Operating Style

During the interviews participants made comments on how the video subject's loading operations were what was described as 'rough' or 'smooth'. Interestingly, however, while there was generally agreement about what work practices were helping or not helping meet the process's objectives, there was not much agreement about what was meant by the descriptors 'rough' or 'smooth' as ways of operating and whether the operating in the subject video was one or the other.

All agreed that the operator in the video was quick at loading trucks and that the daily production was good for a single loader crew but there was little agreement over the subject operator's style. Examples of this variation include:

P4 said *"…and smooth. Like nothing, you'd see it, the logs are just hanging, they're not swinging around. The grapple's not all over the place. He's in control of it ",* P1 said *"…he's a bit rough around the edges, but he's getting the job done."* 'Smooth' or 'rough' was interpreted, therefore, to be a subjective view on the style of operating that required some further definition to establish the relevance of style to the effectiveness of the work practices.

Defining what was meant by the operating style happened through prompting the participant for detail in response to relevant comments. When questioned some participants were able to articulate what they thought was meant by the labels 'rough' and 'smooth'. P5 talked about the speed at which the activities were undertaken: *"I've always been smooth and slow is faster than trying to rush, and you need to be a little more calculated I feel anyway"*. P8 pointed out that the subject operator did not appear to be *"frantic when he's slewing back. I see a lot of people, they want to be quick, and they all think that, when your grapple is empty, you can just frantically slew your way back all the way and then grab the next grab. They think it speeds up time"*. For P7 it was about the force being used to complete the process: *"And then he's giving it a shove and then because he's given it a shove, it's popped over whatever it's sitting on then that makes the whole machine rock around."* P8 also talked about not doing more than what was required to achieve the action's objective: *"He's maintaining a slow speed and making sure that he's not over-slewing and having to come back onto it … and he's not over-lifting here. He's not going way above the trailer and then coming back down on it … he's anticipating the height that he needs to be at for his logs to be in the bolsters and then able to go in."* From those references it appeared that being 'smooth' was something about:

1. The speed at which the machine completed its actions in response to the operator's commands.
2. The force that was applied to any action.
3. The accuracy of the machine's actions.

All of which required some ability of the operator to anticipate what the machine would do in response to their commands. The objective, therefore, with each beneficial practice is to move the machine at a speed at which the operator can maintain a high degree of control over the machine's responses to their actions on the commands. Often, slower is actually faster. The operator should be looking for smooth transitions between each of the machine's responses rather than pulling hard on the control. Precise movements of the controls make for faster, safer loading with less wear and tear.

Conclusions

Five loading operation processes and twenty-seven practices beneficial to fulfilling the objectives of three key loader operator roles and have been described using the input of nine experienced loading operators and two with less experience. Describing loading

operations in terms of its constituent practices highlights the dependence that the function of loading trucks has on its preceding processes (particularly setting out the skid efficiently and stacking logs). While loading trucks is relatively easy to capture on video, (suggesting that video has potential for use as a feedback tool), video is unnecessary for understanding the contributing processes. That means that any feedback given about practices being observed in video footage does need to consider the preceding practices that may have contributed to the observed truck loading performance. However, that level of dependence also means that, regardless of performance in the contributing processes, the measure of loading operation performance is the speed at which a truck can be loaded for any given log grade, something that is observable through video. That fits in well with the use of video for feedback because performance change can be assessed using an objective measure that can be monitored over time. Having described the beneficial practices of loading operations the project is now able to test the potential of video as a feedback tool.

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