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Behavioural profile effect of forestry machine operators in the learning process

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Abstract: A lack of efficient operators for wood harvesting machines poses a great challenge. Here, our objective was to evaluate the effect of the behavioural profile on the productive efficiency of forwarder operators. The study was carried out in a Brazilian company, with a sample of 10 operators. A profile evaluation characterized the reference profile, comparing with the profile of the operators studied. The operators were evaluated through their productive efficiency, for 11 months to track learning curves. The results showed that operators must be attentive to details, deadlines, rules, be patient and a moderate initiative taker. The operators were classified into two behavioural profiles, class 1 appropriate to the position and class 2 with some inappropriate points. The productive efficiency of the operators increased during the training, with the profile operators 1 and 2 reaching the targets set by the company in the fifth and seventh month, respectively. The difference in the average productive efficiency between the operators of profile 1 and 2 during the training process was 19%.

Keywords: wood; operator recruitment; learning curves; productivity

The planted forests are sustainable, ecological and economical industrial base in Brazil. The industry enables the production of 91% of the country's timber products without native forest deforestation (IBA 2017).

Timber harvesting is of great economic importance within the forest industry, accounting for 50 to 70% of the cost of the wood put into factories (Machado 2014).

In addition, the cost of timber harvesting is strongly influenced by productivity. Many factors directly affect the productivity of the forest harvest process, such as terrain, declivity, spacing, tree species and the operator performance, mainly due to the technological advances of forestry machines and equipment, which are increasingly modern high productivity, ergonomics and operational safety (Akay, Sessions 2004; Contreras et al. 2016).

Currently, the greatest challenge faced by Brazilian forestry companies is the training of machine operators with the appropriate job profile, considering that people have different knowledge, behaviours and skills (Purfürst 2010).

Some researchers argue that people have different characteristics, behaviours and abilities, which can positively or negatively affect their work performance. However, the big question is how much the profile affect the efficiency, and yet if it is possible to

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achieve a stable and perfect performance in a certain activity with only practice, without requiring any "natural talent". A natural talent is developed from childhood and it is closely linked to the motivational sources of each individual. Among the different capacities or requirements, the behavioural profile should be a requirement for a forestry machine operator, which consists in the natural predisposition of the individual for a particular job (Kanfer, Ackerman 1989; Ackerman 1998; Buckingham, Clifton 2006; Guadagnoli, Lee 2010).

Tacit knowledge is a spontaneous reaction of action through an operation, which can affect the time and efficiency of human learning, through the ability that the individual develops in the execution of a given task (Reber 1989; Adloff et al. 2015). Yet, operators with the same training level can present a large difference in productivity during the training period, and besides the training process, there are other variables responsible for the efficient performance of the operators (Purfürst 2010).

Buckingham and Clifton (2006) further claim that the lack of professionals with the appropriate behavioural profile for the position may lead companies to act with only 20% of their productive potential. In addition, studies in the forest area indicate a variation in productivity caused by the human factor on the order of 20 to 50% during the process of training forest machine operators. Therefore, it is necessary that the operators have tacit knowledge or natural abilities related to their personality (Harstela 2004; Volodina et al. 2015).

The objective of this study was to evaluate the effect of the behavioural profile on the productive efficiency of forwarder operators in the extraction of wood. We suggest these results can be used for the selection process of future forest machine operators.

MATERIAL AND METHODS

This research was carried out in a forest company located in the state of Mato Grosso do Sul, Brazil, between the geographic coordinates of latitude 20°45'04"S and longitude 51°40'42"W and average altitude of 318 m (Fig. 1), in planted forests of the hybrid *Eucalyptus grandis* X *Eucalyptus uroplylla*. The management regimen was a final cut at 7 years old, the average stocking density was 1,208 trees per ha and the mean individual volume was 0.25 m³.

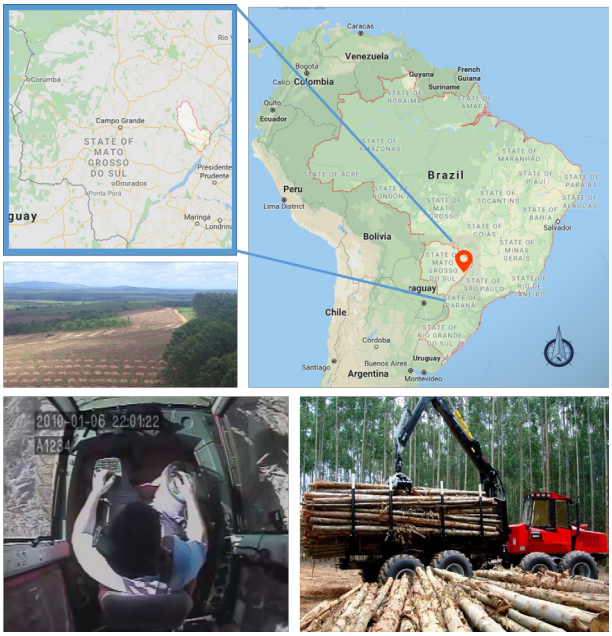

Fig. 1. Study area in Brazil, used machine and workstation of evaluated operators

The harvesting system used by the company was the Cut to Length, consisting of a harvester for the felling of trees and processing into 6-meter logs extracted by a forwarder from the interior to the edge of the field. A sample of 10 male forwarder operators was studied. They were trained internally by the company itself during a total workload of 360 h.

Initially, the reference profile for the forwarder operator was developed, based on a questionnaire applied to several professionals working in the area of training forest machine operators, thus allowing

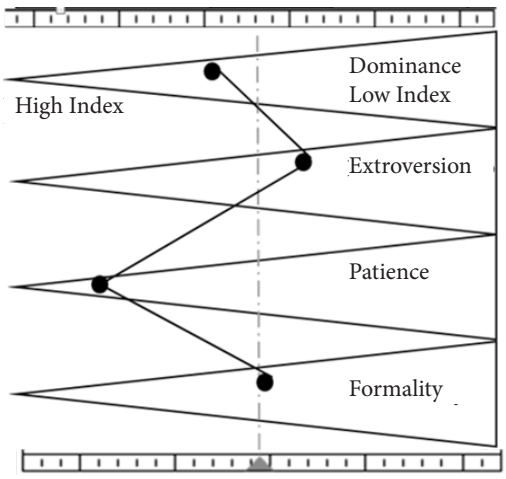

Fig. 2. Representative graph of the behavioural profile main variables, used to evaluate the machine operators

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identification of the ideal characteristics for the position of forwarder operator.

Then, a behavioral profile analysis tool was applied to the studied operators, that obtain information related to dominance, extroversion, patience and formality (Fig. 2), which were later analyzed to characterize the behavioral profile of the operators.

Next, operators were grouped into behavioral profile classes, by the profile analysis tool, based on the following requirements defined as the reference profile: (a) operator fully meets the requirements of the function; (b) operator will need some effort to meet the function requirements.

The productive efficiency of the operators in the profile classes was evaluated from their productivity data obtained from the daily bulletins of the machines provided by the company during the 11-month period. Productivity was defined as the percentage relation between the productivity obtained by the operators in relation to the target of productivity expected by the company, according to Eq. 1:

$$EP = PR/M \times 100 \quad (1)$$

where:
EP – productive efficiency (%);
PR – productivity ($m^3 \cdot h^{-1}$);
M – productivity goal ($m^3 \cdot h^{-1}$).

The average productivity goal used was established by the company according to the specific characteristics of each stand, according to Eq. 2:

$$M = \frac{Aj \times PrM}{Va} \times he \times \frac{TTh}{24} \quad (2)$$

where:
M – productivity goal ($m^3 \cdot h^{-1}$);
Aj – adjusted productivity ($m^3 \cdot h^{-1}$);
PrM – production target ($m^3 \cdot day^{-1}$);
Va – target volume ($m^3 \cdot day^{-1}$);
he – actual hours of work ($h \cdot day^{-1}$);
TTh – total hours worked per day.

Finally, from the data of the productive efficiency given the productivity goal over the 11-month period, we obtained the learning curves of the operators in both profile classes. A randomized complete block design was used, defining the operator profile classes as treatments and the evaluated months as blocks.

The Bartlett test was applied to test the homogeneity of the treatments' variances and the analysis of variance was performed, and when necessary, the means of the treatments compared to each other by the Tukey test at the 5% probability level. A regression analysis was also performed aiming to evaluate the relationship between the variables productive efficiency in relation to training period. The models were adjusted, referring to the relationship between productive efficiency (Y) and training time (X) for each one of the behavioral profiles groups.

The models were analyzed from the following statistics: adjusted coefficient of determination (R^2adj), standard error of estimation (S_{yx}, S_{yx} %) and graphic analysis of residues.

RESULTS

According to the behavioral profile assessment interpretation, the ideal forwarder operator profile for the position should have the following characteristics:

Focus: Must be work-oriented, have high standards of accuracy, and comply with established rules and deadlines.

Pace of work and variety of activities: The individual must have moderate pace, be calm in performing repetitive tasks, being able to complete the functions to the details and quality.

Decision making: The individual must adhere to the guidelines and procedures established by the company, avoiding operational risks.

Communication and collaboration: Must be able to communicate in a formal and sincere manner, not having great extroversion, and have more introspective characteristics. Performing individual work with concentration, without the need for parallel conversations or constant pauses.

Leadership style: Must be a technical expert, and, must be an expert in his field of work. However, even if he is not very extroverted, if requested, he should present the ability to lead by example.

The results showed that the studied operators had two distinct behavioral profile patterns, according to their behavioral characteristics in relation to the requirements for the position of forwarder operator defined in the reference profile. The characteristics of the operators in the profile classes were:

Profile Class 1: Operators who are attentive to details, committed to deadlines and rules, able to avoid risks, patients, technically oriented and adapted to repetitive tasks.

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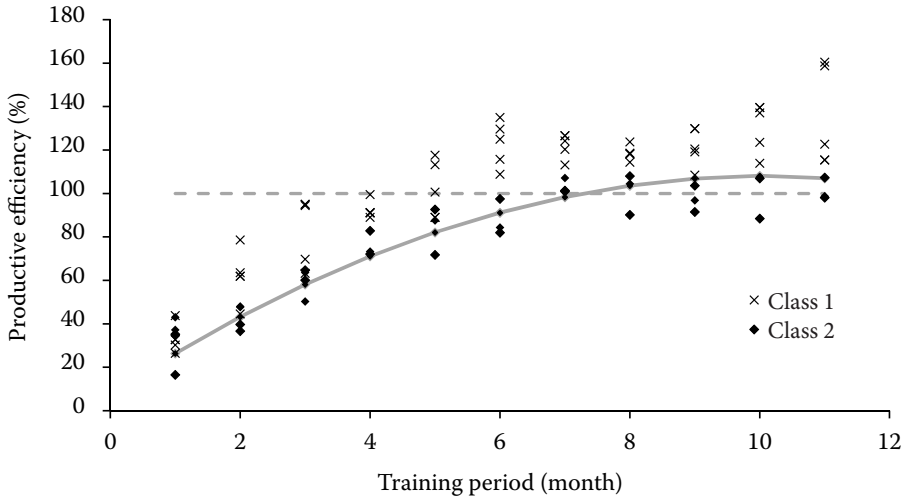

Fig. 3. Average values of productive efficiency, obtained by the operators in the two profile classes, during the training period

Profile Class 2: Very patient and slow paced operators, to the cost of their deadline commitment. Technically oriented and attentive to detail.

Fig. 3 shows the curve of the productive efficiency of the operators in the formation period. The average productivity target used was 40 $m^3 \cdot h^{-1}$.

As can be seen, from the sixth month, no production deficit was observed, and after this period, there was an increase in productive efficiency, with values above the established target. Therefore, it is noted that the average for the training period of forwarder operators under the conditions studied was approximately 6 months.

In addition, it is observed that the profile of the operators was relevant in the training period, since the operators of the profile class 1 reached the production goal from the fifth month of operation, while in class 2 not until the seventh month of operation, with a significant difference ($P < 0.0001$) between the operators of the profile classes (Fig. 4).

The operators of the profile class 1 presented an average productive efficiency of 19% higher than the operators of profile class 2, without much variation in the evaluation period.

The operators of the profile class 1 were considered very patient, but with a dominant characteristic in the commitment with the deadlines, characteristics that had a positive effect on the operation, since the operators are motivated to be constantly seeking to meet the production targets.

Table 1 shows the estimates of the adjusted model with the adjusted coefficient of determination (R^2adj) and standard error of estimate (S_{yx}).

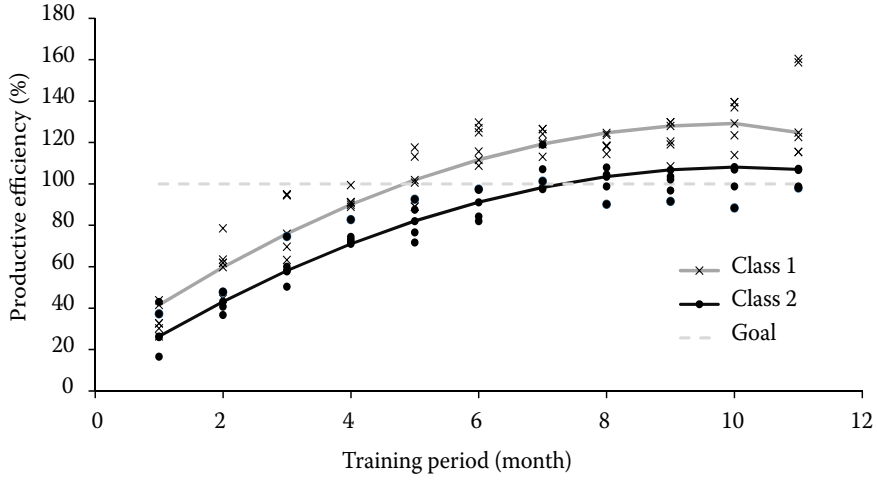

Fig. 4. Estimated productive efficiency curve of forwarder operators in both profile classes, during the training period

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Table 1. Estimates of production efficiencies adjusted with respective adjusted determination coefficients (R^2adj) and standard error of estimate (S_{yx}) with respect to the formation period (x):

Profile class	Equation	Coefficient	R^2adj	S_{yx} (m)	CV (%)
1	$y = 0.2111 + 0.2151x - 0.0107x^2$	$b_0 = 0.2111$ $b_1 = 0.2151$ $b_2 = -0.0107$	0.86	0.12	8.7
2	$y = 0.0754 + 0.1976 + 0.0097x^2$	$b_0 = 0.0754$ $b_1 = 0.1976$ $b_2 = -0.0097$	0.86	0.11	8.2

DISCUSSION

The forwarder machine operator function is really repetitive and needs great attention to details, patience and yet commitment with deadlines. Those are the strongest characteristics that the reference profile provided, and should be the most important topic to be evaluated in a recruitment phase of forest machine operators. These results corroborate with the findings on the study of harvester machine operators for Lopes and Pagnussat (2017).

The operators of the profile class 1, considered very patient, but with a dominant characteristic in the commitment with the deadlines, characteristics that had a positive effect on the operation, since the operators are motivated to be constantly seeking to meet the production targets.

However, due to the fact that their patience is also at high level, the operation is not tiring and stressful for the operator. Therefore, it is important to note that although patience is fundamental in the profile of a machine operator, in order for the operator to have a good productivity and to maintain the pace, he must have an even greater commitment to deadlines and rules.

Comparing the profile evaluation with the productive efficiency we can observe that although the profile 2 operators present positive characteristics, such as patience and commitment to work, these characteristics can be affected by having a slower rate. This is because the characteristics "patience" and "commitment to deadlines and rules" are reversed in relation to the operators of profile 1, that is, this group is presented to be much more patient than committed to deadlines and rules.

Analyzing the productivity curve adjustment statistics for each profile class during the training period, it is noted that the model presents satisfactory R^2adj and S_{yx}, indicating the time as an important variable in the operator's performance. The learning curves and the development of the operators presented consistent results, being able to be a source of future comparison to subsidize processes of selection and training of forwarder operators.

Yet the lack between operators' class 1 and 2 was high, in other researches, with wood harvest machine operators the authors found differences in learning curves could be larger and can make learning time longer and costlier. Studies indicate that the productivity differences caused by the human factor have the average of 20 to 50% and during the process of training, the difference in productivity between operators can be even greater (Glöde 2001; Kärhaä et al. 2004; Ovaskainen 2005; Purfürst 2010).

CONCLUSION

The forwarder operators with the best behavioral profile for the task have, as relevant characteristics, attention to details, commitment to deadlines and rules, ability to avoid risks, patience, and are technically oriented and adapted to repetitive tasks.

The behavioral profile is a variable that affected the productive efficiency of the forwarder operators during the training period, in the different classes evaluated.

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