

$$\frac{\mathcal{E}_2 \quad \rho \vdash_{\Delta} \langle x, \sigma_2 \rangle \rightarrow_e \langle 0, \sigma_2 \rangle}{\mathcal{E}_3, \quad \rho(x) = \ell x \quad \sigma_2(\ell x) = 0}$$

$$\frac{\mathcal{E}_8 \quad \rho \vdash_{\Delta} \langle x=0, \sigma_2 \rangle \rightarrow_e \langle 0=0, \sigma_2 \rangle}{\rho \vdash_{\Delta} \langle \text{not } x=0, \sigma_2 \rangle \rightarrow_e \langle \text{not } 0=0, \sigma_2 \rangle}$$

$$\frac{\mathcal{E}_5 \quad \rho \vdash_{\Delta} \langle 0=0, \sigma_2 \rangle \rightarrow_e \langle \text{true}, \sigma_2 \rangle \quad \mathcal{E}_8 \mathcal{E}_7}{\rho \vdash_{\Delta} \langle \text{not } 0=0, \sigma_2 \rangle \rightarrow_e \langle \text{false}, \sigma_2 \rangle}$$

$$\rho \vdash_{\Delta} \langle \text{not } x=0, \sigma_2 \rangle \xrightarrow{*e} \langle \text{true}, \sigma_2 \rangle$$

5

$$\frac{\mathcal{E}_{10} \quad \rho \vdash_{\Delta} \langle \text{not } x=0, \sigma_2 \rangle \xrightarrow{*e} \langle \text{false}, \sigma_2 \rangle}{\rho \vdash_{\Delta} \langle \text{while not } x=0 \text{ do } x:=x-1, \sigma_2 \rangle \rightarrow_c \sigma_2}$$

$\rho(x) = \ell x \quad \sigma_2(\ell x) = 0$