$|\emptyset_n\rangle$ in terms of the $\{|\psi_j^k\rangle\}$ basis. The appropriate state assigned to the ensemble E in the context C_k will be the following:

$W_k = \Sigma_j w_j^k |\psi_j^k\rangle\langle\psi_j^k|$, where $w_j^k = \sum_n w_n |c_j^n|^2$, that is:

$$W_k = \sum_j (\sum_n w_n |c_j^n|^2) |\psi_j^k\rangle\langle\psi_j^k|$$

$$= \sum_{j,n} w_n |c_j^n|^2 |\psi_j^k\rangle\langle\psi_j^k| .$$

We now have the following:

$$\mathrm{Tr}(W_{qm} M_s) = \mathrm{Tr}[(\sum_n w_n |\emptyset_n\rangle\langle\emptyset_n|)(\sum_j a_j^s |\psi_j^k\rangle\langle\psi_j^k|)]$$

$$= \mathrm{Tr}\{[\sum_n w_n (\sum_m c_m^n |\psi_m^k\rangle)(\sum_r c_r^{n*} \langle\psi_r^k|)](\sum_j a_j^s |\psi_j^k\rangle\langle\psi_j^k|)\}$$

$$= \mathrm{Tr}(\sum_{n,m,r,j} a_j^s\, w_n\, c_m^n\, c_r^{n*} |\psi_m^k\rangle\langle\psi_r^k|\psi_j^k\rangle\langle\psi_j^k|)$$

$$= \mathrm{Tr}(\sum_{n,m,r} a_r^s\, w_n\, c_m^n\, c_r^{n*} |\psi_m^k\rangle\langle\psi_r^k|)$$

$$= \sum_{n,m,r,t} a_r^s\, w_n\, c_m^n\, c_r^{n*} \langle\psi_t^k|\psi_m^k\rangle\langle\psi_r^k|\psi_t^k\rangle$$

$$= \sum_{n,t} a_t^s\, w_n\, |c_t^n|^2 ,$$