Social Networks in the Employed Cooperative Problem-based Learning Environment

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Analysing social Network activity

In-degree interaction value: The number of learners who actively interact with a certain learner in the cooperative problem-based learning environment. The in-degree interaction value can be formulated as:

$$R_{\ln(n)} = \sum_{m=1}^{t} c_{m,n}$$

where $R_{\ln(n)}$ stands for the in-degree interaction value of the n^{th} learner, $C_{m,n}$ is set to 1 if the m^{th} learner actively interacted with the n^{th} learner; otherwise, $C_{m,n}$ is set to 0, and t is the total number of learners excluding the n^{th} learner in the cooperative problem-based learning environment.

Out-degree interaction value: The number of learners who accept interactive request from a certain learner in the cooperative problem-based learning environment. The out-degree interaction value can be formulated as

$$R_{\mathrm{Out}(n)} = \sum_{m=1}^{t} c_{m,n}$$

where $R_{\mathrm{Out}(n)}$ is the out-degree interaction value of the n^{th} learner, $C_{m,n}$ is set to 1 if the m^{th} learner accepts
interactive request from the n^{th} learner; otherwise, $C_{m,n}$ is set to 0, and t is the total number of learners excluding the n^{th} learner in the cooperative problem-based learning environment.

Linked interaction value: The number of learners who have bidirectional interaction with a certain learner in the
cooperative problem-based learning environment. The linked interaction value can be formulated as

$$R_{\mathrm{Iv(m.n)}} = \sum_{m=1}^{t} (c_{m,n} \times c_{n,m})$$

where $R_{\mathrm{Iv(m.n)}}$ is the linked interaction value of the n^{th} learner with the m^{th} learner, $c_{m,n} \times c_{n,m}$ is equal to 1 if the bidirectional interaction exists between the n^{th} learner with the m^{th} learner; otherwise, $C_{m,n}$ is equal to 0, and t is the total number of learners excluding the n^{th} learner in the cooperative problem-based learning environment.

Interactive score: The interactive score is viewed as a weight score of interactive level between a learner with the other learning peers in the cooperative problem-based learning

environment. According to quarter method of the statistics, this study divides all learners into four interactive intervals and assigns various weight scores for different interactive levels based on the linked interaction values of all learners. The Interactive score can be formulated as

$$I_n = \begin{cases} 4, R_I \geq R_{(top\ 25\%\ high)} \\ 3, \quad R_{(top\ 50\%\ high)} \leq R_{Iv} \leq R_{(top\ 25\%\ high)} \\ 2, \ R_{(top\ 75\%\ high)} \leq \ R_{Iv} \leq \ R_{(top\ 50\%\ high)} \\ 1, R_{Iv} \leq R_{(top\ 75\%\ high)} \end{cases}$$

where I_n is the interactive score of the n^{th} learner, $R_{(top\ 25\%\ high)}$ is the interactive interval whose learners' linked interaction values are the top 25% high, $R_{(top\ 50\%\ high)}$ is interactive interval whose learners' linked interaction values are the top 50% high, and $R_{(top\ 75\%\ high)}$ is the interactive interval whose learners' linked interaction values are the top 75% high.

Social score: The social score represents the social position of a leaner in the cooperative problem-based learning environment. Suppose the n^{th} learner interacts with the m^{th} learner. The social score is formulated as

$$S_n = \sum_{m=t}^{t} (c_{m,n} \times c_{n,m} \times I_m)$$

where S_n is the social score of the n^{th} learner in the cooperative problem-based learning environment, $c_{m,n} \times c_{n,m}$ is equal to 1 if the bidirectional interaction exists between the n^{th} learner with the m^{th} learner; otherwise, $c_{m,n} \times c_{n,m}$ is equal to 0, I_m is the interactive score of the m^{th} learner, and t is the total number of learners excluding the n^{th} learner in the cooperative problem-based learning environment.

Based on Eq. (5), when the n^{th} learner interacts with the m^{th} learner, the n^{th} learner can get the interactive score of the m^{th} learner, and the m^{th} learner can also get the interactive score of the n^{th} learner in the cooperative problem-based learning environment. Here, we further illustrate an example to explain how to compute social scores for individual learners in the employed cooperative problem-based learning environment.