Development of a learning model for large class cohorts to strengthen students learning outcomes based on differentiated instruction

[1,^]Siva PR Muppala and [2]Chandramohan Balasubramanyam

School of Engineering and the Environment, Kingston University London
Friars Avenue, Roehampton Vale, London, SW15 3DW, United Kingdom

[2]Institute of Commonwealth Studies
School of Advanced Study
University of London
Senate House, Malet St, Bloomsbury, London WC1E 7HU

Abstract

We propose a new sequential numeral-division-based approach to classroom learning. It takes into roots from the concept of trichotomy – division of students based on creamy-level, middle-level and weaker-level students, proposed by the present authors. A sequenced series of formative assessments can map student progress and achievement, particularly in the case of weaker students. The idea behind the development of this model is to study if weak students perform better on critical-thinking tests in a collaborative learning setting rather than when they study individually. We propose a mathematical model to measure group activity/achievement, which is a complex function of several parameters. We collect data on different parameters for validation of the model and hope to publish the findings in 2020-21.
Keywords: numerical learning model, measurement/quantification of learning, formative assessment, large class cohorts, weaker students, group learning

Introduction & Literature

This study proposes a new sequential numeral-division-based approach. The concept of this classification (division and classification are used interchangeably) of the students based on their learning levels/abilities is presented in a very recent paper by the present authors [1]. This approach is targeted at large class cohorts because the division is more evident. This mode intertwines formative and summative assessments in equal or unequal numbers that provides an excellent balance between face-to-face sessions and online learning, both self-directed and collaborative with other students [2, 3]. Brookfield [4] opines that online learning has a better advantage as detailed feedback can be given to individual student more than in face-to-face learning. It also helps to identify and offer more support to weaker students. This division in a group learning/flipped classroom was used to create student groups, whose sizes varied from individual learner to a flexible grouping no more six in a cooperative activity. Such an activity, ideally, allows the students to take responsibility by themselves and capacitates them to investigate into themselves in the given tasks.

A sequence of series of formative assessments demonstrates progressive achievement, particularly for weaker students to help improve their technical proficiency and improve their module marks. Therefore, development of a flipped learning template is an ideal way to plan, deliver and evaluate this approach. Or, an alternative and effective option is the development of a sequential empirical mathematical model to generate quantitative data to assess the knowledge gains of a student involved in the collaborative learning [5, 6]. In this paper, we only present the details of the model and its validation is for the future study. The idea behind the development of this model is to study if the students in a collaborative learning perform better on critical-thinking tests than students who do individually. In other words, it is to map the weaker students' self-knowledge of the academic learning, and to measure it. Literature shows that very little work has been carried out on this problem. For example, Richardson [7] says there is no evidence why there is attainment gap between BME and white students. To partly answer this question, in an internally funded interdisciplinary project at Kingston University, Hill et al. [8] in their comparative studies based on three module Levels 4 to 6 reason that to understand the attainment gaps is more effective in large class cohorts and through better inclusive assessment methods; one of them is group assessment. Brookfield [4] p137 says that *working in teams is the norm, so it makes perfect sense for the pedagogy to mirror* working life.

Modelling

We propose a design to measure this group activity that is a complex function of several parameters, see Eq. (1). We will carry out this study in future to this parametric data through a series of questionnaires during the running of the modules. The first step is to formatively assess the prior knowledge, ending with the module feedback. This approach takes its roots in another research area, Combustion, where a flame model is proposed by the first author

$$S_T = S_{L0} + a\, f\left(S_{L0}^{\alpha} \cdot (u')^{\beta} \cdot \alpha^{\gamma}\right)\left(\frac{p}{p_0}\right)^{\delta} \qquad \text{Eq.1}$$

where the turbulent flame speed S_T, or equivalently combustion heat release, is a strong function of flame and turbulent flow quantities [9]. Further discussion on this model can be found in the first author's work [9]**.**

Here the first term is laminar flame speed S_{L0} that is equivalent to pre-knowledge of the student, K_0 in Eq. (2a). For zero turbulence, the turbulent flame speed S_T is equal to laminar flame speed S_{L0}. Here, S_T is $\equiv$ of learning outcomes (LOs) in group learning (the triple bar notation is equivalent ($\equiv$). It is interesting to note that assuming that the student does not gain any knowledge (because of his/her no contribution or learning or also if the group size is infinite) in the module, s/he still holds her/his pre-knowledge, K_0.

$$K_c = K_0 + a\, f\left(K_0^{\alpha} \cdot e^{\beta} \cdot l^{\gamma}\right)\left(\frac{1}{N-1}\right)^{\delta} \; where\, 1 < N \leq 5 \qquad \text{Eq.2a}$$

where *f* denotes mathematical function. Here, the pre-constant *a* is an adjusting factor as a function of learning environmental constraints. Higher level of degrees of freedom means higher the learning. Here, K_0 is the previous knowledge of the learner, *e* is a measure of the environment conducive to learning, l is the level or amount of information communicated which is given as the product of duration of exposure or communication and rate of communication, among the students in that particular group. N is the number of students not exceeding four in a group. The exponential constants have to be estimated from measured data. These quantities are the input parameters required to evaluate the quantity K_c. K_c is a measure of the level of attainment by a learner through problem-based learning (PBL). The maximum value the learner can attain is set to unity. It is assumed that the knowledge gained by the learner within the group-learning environment cannot exceed the defined cognizance of the leading student (whose K_c is value unity).

In this sequel Eq. (2a), the analytical model is expected to estimate the levels of learning achievements – such as test scores. N=5 is seen the optimal value for conducive learning. Hunt [8] page 52, promotes the advantages of problem-based learning and collaborative projects, Twyman and Heward [10] list twelve low-level technology strategies that work in any classroom, especially for group working. Our classroom experience shows N>5 lowers the learning levels. The learning characteristics are captured in an abstract way, and the exponents of parameters in Eq. (1a) are evaluated ad hoc firstly from experiments. These parameters are student's previous knowledge in the appropriate subject, learning environment, duration of contact or discussion and level of communication with peers, workload under which s/he works in a particular group and number of students involved. The mathematical relation in the problem-based learning is

$$K_c = K_0 + a\, f\left(K_0^{\alpha} \cdot e^{\beta} \cdot l^{\gamma}\right)\left(\frac{1}{N-1}\right)^{\delta} \; where 1 < N \le 5 \qquad (2b)$$

By dividing Eq. 1 by K_o yields

$$\frac{K_c}{K_0} = 1 + a\, f\left(K_0^{\alpha-1} \cdot e^{\beta} \cdot l^{\gamma}\right)\left(\frac{1}{N-1}\right)^{\delta} \quad 1 < N \le 5 \qquad (2c)$$

The conditions/limits of Eq.2a (or 2b) of the model:

1. It is devised for group learning, and not applicable to independent learner. That is, for N equals unity, the equation becomes invalid.
2. We believe the model yields more promising results for $1<N \le 5$, and the optimistic for the whole number, N=5 [1].
3. Mathematically, although the equation Eq.(2a) is still valid for any N value, practically, the quality of learning diminishes for N>5 and thus the equation has little significance for higher N value.
4. From above point, for a hypothetical case $N = \infty$ (infinity), the second complex term becomes zero i.e., K_c becomes $1/(N-1) \sim 1/\infty \sim 0$; i.e. state of no learning.
5. Overall, the intended purpose of this model is to measure the LOs for all students with transparency, make the quantitative data available to the wider community and for future validation purposes (see [11] for extensive discussion on the policies to address challenges in achieving standardized LOs for all students of all varied cognitive skills).

The other basic assumption that governs the development of this model is that the students who participate in collaborative learning perform better on the critical-thinking test than students who do individually.

Normalization of the above relation Eq. (2c) is

$$\frac{K_c}{K_0} = 1 + a\ f\left(K_0^{\alpha-1} \cdot e^{\beta} \cdot t^{\gamma}\right)\left(\frac{1}{N-1}\right)^{\delta} \qquad (2d)$$

The normalization of all quantities satisfies dimensional homogeneity of an equation.

Discussion

In the design of this model we consider that the students are deeply engaged in learning activities and show their dedicated involvement in interacting with the group members. Other simplifications include the learner that is much weaker, in relative terms, to the leading student (LS) benefits more than other students in the group. The learner is supposed to have appropriate basic subject knowledge from the pre-university studies. This influence on the learner may be accounted in the exponent δ that is taken to be equal to unity for a group not exceeding five students. It is also assumed that there is only one leading student within a group who demonstrates a thorough knowledge and understanding of conceptual and applied aspects of that particular subject. The exponent varies between 1/4 and 1/3, adopting from the original formulation Eq. (1). This rise in the exponent indicates lowering of the level of connectivity among the group members and hence, the learning outcomes. To obtain comprehensive results, the parameters and exponents in equation 1 should be derivable following detailed interpretation of the data collected from diverse student cohorts and compared with literature [8] based on BME/non-BME, UK-EU/international, disability/dyslexic students and genders. This interpretation will form the basis of a future study by the authors.

Conclusions

A model is proposed here and its validation is a challenge for several reasons:

i) It is a novel approach, mathematically, and thus requires definite data to show its workability
ii) there is very little quantitative data available in the literature.

On the positive side,

a) the workability in one classroom setting can be extended to a different classroom, or another subject because all measurable quantities are normalized.
b) the findings can be used as a reference for comparative study of new data.

We will be collecting additional data during the academic year 2020-21 and hope to further developing this model. We welcome comments and suggestions, which will be acknowledged in the publication.

References

1. Muppala, S.P.R., and B Chandramohan, *Classroom Research in Large Cohorts: an innovative approach based on questionnaires and Scholarship of Teaching and Learning on Multiple-Intelligences.* Journal of Education and Learning, 2020. 9(3).

2. Fallows, S. and Chandramohan, B., *Multiple Approaches to Assessment: Reflections on use of tutor, peer and self-assessment.* Teaching in Higher Education : Critical Perspectives, 2010. 6(2): p. 229-246.
3. Muppala, S.P.R., and Chandramohan, B., *A quantative approach to Problem-Based-Learning based on a Questionnaire: a model for student learning outcomes (a case study)*, in *3rd EuroSoTL Conference*. 2019: Bilbao, Basque Country.
4. Brookfield, S.D., *ecoming a Critically Reflective Teacher*. 2/e ed. 2017: JOSSEY-BASS, A Wiley Brand. (in pages 135–137)
5. Das, B.M., and Sartore-Baldwin, M. L., *Development of a Logic Model for a Service Learning, Dog Walking Course for College Students.* Evaluation and Program Planning, 2019. 76: p. Article 101667.
6. Munir, M.T., Baroutiana, S., Young, B.R. Carter, S., *Flipped classroom with cooperative learning as a cornerstone.* Education for Chemical Engineers, 2018. 23: p. 25-33.
7. Richardson, J., *The under-attainment of ethnic minority students in UK higher education: what we know and what we don't.* Journal of Further and Higher Education, 2015. 39(2): p. 278-291.
8. Hill, N., Denholm-Price, J., Atkins, N., Dourado, T., Nimoh, L., Nigel, P., *Does group assessment impact BME attaintment?* New Directions in the Teaching of Physics, 2016. 11(1).
9. Muppala S.P.R, Aluri, N.K., Dinkelacker, F., Leipertz, A., *Development of an algebraic reaction rate closure for the numerical calculation of turbulent premixed methane, ethylene, and propane/air flames for pressure up to 1.0 MPa.* Combust. and Flame, 2005. 140: p. 257-266.
10. Twyman, J.S. and Heward, W.L., *How to improve student learning in classroom now*. Inter. Journal of Educational Research, 2018. 87(78 - 90).
11. Liebermann, A., and Miller, L., *Teacher Leadership*. 1/e ed. 2004, San Franscisco, CA: John-Willey & Sons, Inc. pages 6 - 9.