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Prediction and prevention of failure: An early intervention to assist at-risk medical students

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Abstract

Background: Consistent identification and prevention of failure for at-risk medical students is challenging, failing courses is costly to all stakeholders, and there is need for further research into duration, timing and structure of interventions to help students in difficulty.

Aims: To verify the value of a new exam two weeks into medical school as a predictor of failure, and explore the requirements for a preventative intervention.

Methods: Students who failed the two-week exam were invited to a series of large-group workshops and small-group follow-up meetings. Participants' subsequent exam performance was compared with non-participants.

Results: About 71% of students who performed poorly in the new exam subsequently failed a course. Attendance at the workshops made no difference to short- or long-term pass rates. Attendance at more than three follow-up small group sessions significantly improved pass rates two semesters later, and was influenced by teacher experience.

Conclusions: Close similarity between predictor task and target task is important for accurate prediction of failure. Consideration should be given to dose effect and class size in the prevention of failure of at-risk students, and we recommend a systemic approach to intervention/remediation programmes, involving a whole semester of mandatory, weekly small group meetings with experienced teachers.

Introduction

In a context of widening participation throughout higher education, and large resource investment by all stakeholders, there exists a moral imperative to assist struggling students in order to improve their success and their institutions' retention rates. The challenge is that these students typically fail to seek help (Winston et al. 2010a), and continue to underperform throughout their education (Cleland et al. 2005, 2008). Although there is a growing consensus that early identification and intervention provide the best chance of improving these students' skills (Paul et al. 2009), the most effective way to break this "cycle of underperformance" (Cleland et al. 2005) remains an active area of enquiry (Cleland et al. 2013).

Essentially, there are two approaches to assisting these students: prediction and prevention of failure, or remediation after failure. Within medical education, many attempts at remediation have had only short-term effects (Cleland et al. 2013), setting these students up for further failure later in their careers. However, interventions lasting a full year have reported more success (Ficklin et al. 1985; Alexander et al. 2005). In particular, recent work has shown significant long-term gains in student outcomes after participation in a 14-week course that provides a cognitive and affective apprenticeship using self-regulatory, metacognitive, and dialogic techniques within a small community of inquiry (Winston et al. 2010a, 2010b, 2012). These successful efforts at remediation have been preferred to prevention because of the difficulty of predicting exactly who will struggle, the risks of labelling students incorrectly, and the necessity for students to admit their need for help before it can be fully effective. Indeed, most reported efforts at preventing failure have shown no significant effect (Tekian & Hruska 2004; Devoe et al. 2007), or short-term but no long-term effect (Stegers-Jager et al. 2013). Nevertheless, accurate prediction and targeted prevention of failure, if possible, has the potential for more effective use of limited resources.

Accurate prediction of failure is challenging: student difficulty and attrition have complex causes (Hall 2001), and the real social world is inherently too unpredictable for straightforward modelling (Kahneman 2011). The best pre-

Practice points

- Failing an early exam two weeks into medical school is strongly predictive of later student difficulty.
- Consideration should be given to dose effect, class size, teacher experience, and institutional systems in the prevention/remediation of failure of at-risk students.
- Large groups and small doses are ineffective for addressing the change in self-regulatory skills and thinking dispositions needed to turn around marginal performance.

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admission predictor appears to be a combination of prior GPA and cognitive tests such as the US Medical College Admission test (MCAT), which account for ~20% of the variance in medical school performance (Donnon et al. 2007; Callahan et al. 2010). However, these measures seem unable to predict either failure or dropout (Shulruf et al. 2012). Inclusion of personality and study skills inventories may be useful for predicting later "non-cognitive" clinical performance but add little to prediction of the basic science performance that serves as a gatekeeper for those later years (Haight et al. 2012; McLaughlin 2012); besides, such self-report inventories are susceptible to faking, and should be used with caution (Griffin & Wilson 2012).

Unsurprisingly, the more similar the prediction task is to subsequent performance assessment tasks, the more accurate the prediction turns out to be (Tanilon et al. 2011). Second year performance is highly predictive of final performance (Cleland et al. 2008; Rich et al. 2012), and students who struggle or fail in the first year continue to have difficulty later in the same course (Yates 2011; Stegers-Jager et al. 2013). It seems likely that the most effective predictor for "at-risk-ness" is students' performance early in their programmes. Finding an appropriate early measure, and then targeting these students with a carefully designed intervention, would be a worthy goal for effective use of resources for maximizing student outcomes.

Aims

In this paper, we describe an attempt to take ideas from a successful remediation programme (Winston et al. 2010a) and apply them to a short course aimed at prevention of failure. We provide a detailed description of our specific context, our practice, and its consequences (Regehr 2010), and thereby address calls for further research into duration, timing and structure of interventions to help students in difficulty (Cleland et al. 2013). We address the following questions:

- Can a new early exam improve our ability to predict which students will fail courses at our medical school?
- What kind of early intervention can we provide to reduce the failure rate of these students in our own context?

Answering the second of these questions could reduce delay and cost for the students, and the burden on our own remediation programme (Winston et al. 2010a), while potentially offering ideas on how to assist strugglers in other professional education contexts.

Methods

Context

This research was carried out by the first author, KW, a faculty member in the Centre for Teaching and Learning (CTL) of a Caribbean-based US medical school, with ethical approval from the school's Institutional Review Board. The school admits up to 400 new students, three times per year, to follow an accelerated curriculum, spending four four-month basic science semesters on island before advancing to their clinical rotations in mainland USA. Students have diverse backgrounds, with mean MCAT scores of 23 (range is 12–36): most have failed to gain entry into mainland US medical schools, where the mean MCAT of matriculants is 31 (AAMC 2012). Lower MCAT scores have been shown to correlate with lower USMLE pass rates (Tekian & Hruska 2004): we have a 25–30% attrition rate. Prediction of success and failure at these MCAT ranges has proven difficult: MCAT, prior college GPA, age, gender and ethnicity combine to predict only 8.7% of our students' attrition, and 13.4% of variance in their basic science grades (Meisenberg 2012).

In September 2010, the school shifted to a system-based curriculum. During the first semester, students take three sequential modules, taught largely through lectures (20 hours per week) and labs. Each module is assessed through multiple choice exams: 45% of the module grade from an exam at the end of the module, and 45% from a final exam at the end of the semester; the remaining 10% coming from labs. For the first module (Fundamentals, of histology, biochemistry, physiology and anatomy), amid fears of too much weight on students' first medical school exam, the exam was split into two sections: the first part (henceforth referred to as "week-2-exam") is taken after the first two weeks and accounts for 19% of the module grade; the second after five weeks, constitutes 26%. The pass mark for all modules is 60–65%.

Data collection and analysis

Initially, we looked at student performance in the new week-2-exam for three cohorts. For those who failed (scored $<65\%$), we tracked whether they went on to fail courses at the end of that first semester or in any subsequent semester. After a year, the numbers and percentages were so clear that we felt no need for further statistical analysis (Gorard 2010): many students were failing the week-2-exam, and this was predictive of later failure (see "Results" section). Something had to be done, but any intervention needed to fit around the overcrowded schedules of both the students and the CTL faculty.

For the next three cohorts, students who failed the week-2-exam were invited by email to participate in our intervention. This email included a description of the intervention, and data pertaining to the predictive value of this exam drawn from those first three cohorts. Attendance and subsequent performance each semester were tracked, both for those who chose to participate, and those who did not. Pass/fail outcomes were compared with the three cohorts prior to this intervention, and between participating/non-participating students. Given the categorical pass/fail data, chi-squared tests were used to determine the significance of varying levels of attendance. We also performed forced order of entry multiple regression analyses, using SPSS version 19, 2010 edition (SPSS, Inc., Chicago, IL, USA), to determine the effect of likely predictor variables on the number of modules failed at the end of first semester: score on week-2-exam, MCAT score, attendance at the intervention sessions, attendance at other voluntary CTL activities and demographic data. Participating students were also asked four Likert-type questions about the value of the intervention, using the anonymous survey tool SurveyMonkey®.

Intervention design

Given existing demands on students' time, the large number of struggling students, and the small number of overworked CTL faculty, we decided to offer a short series of three large group workshops, in the only open time slots available in the two weeks between obtaining the week-2-exam results, and the second exam at the end of the fifth week. Each workshop lasted two hours, and was held in a large classroom with tables for seating smaller groups of six students. At the conclusion of the workshop series, participants could sign up for weekly small group meetings with a faculty facilitator for the remainder of the semester.

This compromise design was based on our Essential Lifelong Learning Skills (ELLS) course, which draws on a blend of constructivist, sociocultural and complexivist theories to focus on self-regulation, metacognition and reflection while applying active learning skills to basic science content (Winston et al. 2010a). Through discourse, explicit reasoning, and mutual feedback, small groups of repeating students, guided by a faculty facilitator, support each other's cognitive and affective development (Winston et al. 2010a, 2010b, 2012). Although we did not have the resources to offer this intervention in small groups, or over a full semester, we felt that presenting key ideas and then using the majority of workshop time for small group assignments had the potential to replicate some of the findings from the team-based learning (TBL) model, in which weaker students are reported to have attained the largest performance gains (Koles et al. 2010).

Each workshop included large group introduction to, and discussion of, key ideas, small group activities with circulating CTL faculty facilitators, followed by whole-class plenary to share insights. At the end of each workshop students were assigned tasks for applying the learned ideas to basic science course material, and asked to bring back completed assignments for further discussion.

The first workshop included small and large group discussion of the emotions related to the just-failed week-2-exam, with activities focused on students' current study strategies, and exploration of their perception of the meanings of terms like "study", "learn" and "review". After providing a brief overview of self-regulated learning theory (Zimmerman 2000), students were engaged in time-management and lecture-previewing activities, with careful attention to language use and definitions of previously learned terms that were about to appear in upcoming lectures, to demonstrate the importance of linking new learning to prior knowledge (Dewey 1929). The second workshop involved organization and critical appraisal of lecture material, with groups working on asking higher order questions and the creation of study products such as concept maps. The final workshop revolved around techniques for answering and learning from multiple-choice questions, including rephrasing of question stems, explanation of answer choices, and the use of confidence marking for judgments of learning and identification of specific knowledge gaps. In the follow-up small group (4–7 ss/group) meetings, each facilitated by one of six CTL faculty, these ideas were elaborated upon, along with introduction of other activities drawn from the ELLS course (Winston et al. 2010a).

Results

For the first three cohorts of students in the new curriculum, 27% (276/1010) of all those entering the school failed the week-2-exam. As shown in Table 1, 65% (178/275) of students who failed week-2-exam, went on to fail either semesters 1, 2, or 3. This was our strongest early predictor of failure yet. For the next three cohorts, 32% (333/1109) of all those entering the school failed the week-2-exam, and were invited to attend the intervention workshop. As shown in Table 1, whether or not students who failed the week-2-exam were offered our intervention, two-thirds had failed a module by the end of semester 3 – offering the intervention made no overall difference to outcomes. The mean MCAT for students failing the first exam was 22.3, while for those passing it was 23.4: a small, non-significant difference.

Table 2 shows the effects of attending the workshops. 268 of those offered the intervention attended at least one workshop, while 101 attended three workshops. Over the three iterations of this intervention, each workshop had between 30 and 100 students, with numbers decreasing from the first to the third in the series. Workshop attendance also appears unrelated to outcomes.

Over the three intervention cohorts, 91 students signed up to attend the follow-up small group sessions, but only 21 students attended more than two of these sessions, despite having been shown the data demonstrating a strong dose effect for the ELLS course, where increased attendance correlates with better long-term outcomes (Winston 2010a). Table 3 shows that attendance at more than two follow-up sessions correlates with higher pass rates, and is statistically significant for semester 2 pass rates. Also noteworthy is that the experience of the teacher (>25 years for two teachers, compared to <6 years for the other four) appears to be

Table 1. Comparison of students failing week-2-exam from cohorts offered and not offered the intervention.

	% Students passing semester 1	% Students passing semesters 1 and 2	% Students passing semesters 1, 2 and 3
Cohorts not offered intervention, $n=275$	50%	40%	35%
Cohorts offered intervention, $n=333$	53%	41%	34%
$\chi 2$	$p=0.456$	$p=0.833$	$p=0.801$

Table 2. Outcomes for the intervention cohorts, by workshop attendance.

	n	% Students passing semester 1	% Students passing semesters 1 and 2	% Students passing semesters 1, 2 and 3
Attend no workshops	65	45%	38%	30%
Attend 1 workshop	105	57%	43%	33%
Attend 2 workshops	62	56%	35%	32%
Attend 3 workshops	101	51%	42%	38%
$\chi 2$		$p=0.38$	$p=0.791$	$p=0.847$

Table 3. Effect of attendance at small group, post-workshop and follow-up sessions.

	n	% With experienced teachers	% Students passing semester 1	% Students passing semesters 1 and 2	% Students passing semesters 1, 2 and 3
Attend 3–6 sessions	21	86%	67%	67%	48%
Attend 1 or 2 sessions	50	26%	50%	36%	37%
Attend 0 sessions	262	n/a	53%	41%	34%
$\chi 2$		$p < 0.001$	$p = 0.414$	$p = 0.047$	$p = 0.43$

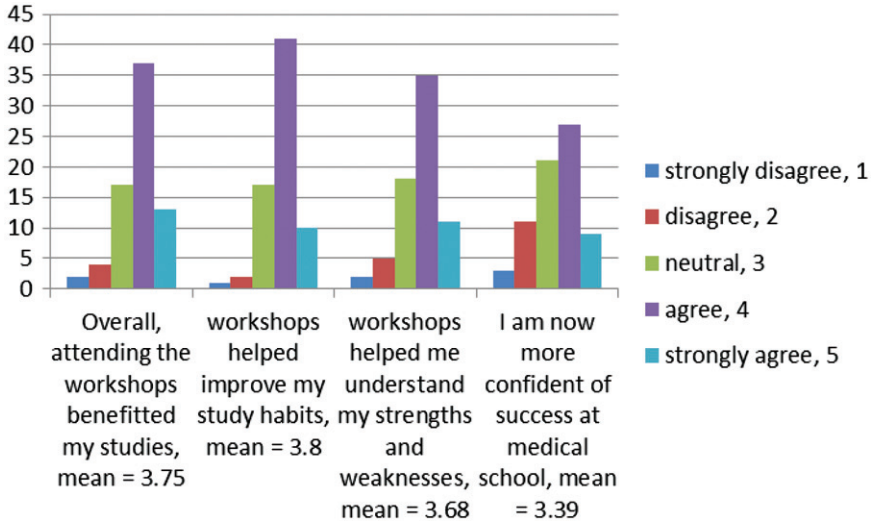

Figure 1. Student survey results, likert-type questions.

strongly related to persistence in attending these voluntary sessions, despite having allocated students according to score on the week-2-exam to ensure an even distribution of "prior knowledge" in each group.

Multiple regression analysis revealed that only two factors were significant predictors for the number of modules failed in semester 1: the actual score on the week-2-exam (F change = 69.1, $p < 0.001$) and attendance at the small group sessions (F change = 9.56, $p < 0.002$). All other factors (MCAT score, workshop attendance, attendance at other activities and demographics) were non-significant (F change < 0.4, $p > 0.5$). Changing the order of forced entry for the regression analyses yielded the same results. Thus, the score on the week-2-exam combined with attendance at the small group sessions to explain 18.4% variance in the number of failed modules in first semester.

There was a 44% response rate to the surveys of workshop participants, with outcomes quite different to the objective data: overall 64% (183/286) of the students agreed or strongly agreed that the workshops were helpful (Figure 1), while only 10% (30/286) disagreed or strongly disagreed with this notion.

Discussion

Our first aim of finding an improved predictor of failure was certainly achieved for our specific population of medical students. This link between early and late performance within the same school mirrors the findings of others, from undergraduate education studies (Tanilon et al. 2011), to medical schools in UK (Yates 2011) and Netherlands (Stegers-Jager et al. 2013), so perhaps measures of early medical school performance are our best indicators of future medical school performance. It may be possible to search for additional variables to improve this level of prediction, but we need to be aware of the inherent unpredictability of complex systems such as education (Mennin 2010), and should, perhaps, focus our efforts on how best to adapt our programmes to help those most likely to struggle.

In educational research, unintended outcomes allow us to explore our assumptions, understand our mistakes and inform future practice (Regehr 2010). The fact that this intervention did not work as well as we hoped provides an opportunity to advance our understanding of how to (and not to) help struggling students. For the remainder of this discussion, we consider aspects of this particular intervention, offer some answers to our second research question of how to reduce the failure rate in our own context, and make a number of suggestions that may help to improve interventions to prevent failure in broader contexts.

Firstly, the diminishing attendance as the workshop series progressed, and minimal take-up of the ensuing, and more effective, small group sessions, is in keeping with the commonly reported limited help-seeking of weaker students (Devoe et al. 2007; Winston et al. 2010a). Others have found that students dislike exercises that have improved their performance (Leggett et al. 2012) and that self-report measures are unrelated to objective outcomes (Bowman 2010).

Given that the skills required for competence are similar to the skills required to evaluate that competence (Kruger & Dunning 1999), it is unsurprising that struggling students are not the best judges of the help provided for them. This reinforces the need for such interventions to be mandatory. Previous work showed that effective remediation with voluntary participation remained equally effective after participation was required (Winston et al. 2010a): it takes time for students to develop the skills and make the commitment of effort needed for real behaviour change. Students' attitudes to remediation become more positive as the programme progresses (Winston et al. 2010b), so it makes sense to require participation in attempts at prevention of failure to afford students the opportunity to appreciate and understand the value of such interventions.

Despite positive student surveys, our large group workshops made no statistical difference to overall pass rates, while the small group sessions appear to have had some effect. Large classes can be alienating and de-motivating (van Etten et al. 2008), while smaller classes promote development of thought and attitude (Edmunds & Brown 2010) and allow for more interaction and teacher attention (Blatchford et al. 2011). Affect is an important element of both reasoning and student engagement (Taylor 2010). Confronted with the prospect of failure, it was difficult for our workshop participants to address the affective aspect of their situation before such a large audience of unfamiliar colleagues. The objective arguments faculty can deliver to a large group in a few meetings may not affect behaviours (Jonas 2010): the positive mood that emerges from familiarity and trust is often a prerequisite for change (Geertsma 1977). Such trust emerges from the relationships that develop in stable groups over time, as students provide mutual motivation and support, and come to appreciate each other's contributions (Winston et al. 2010b). The feeling of group membership and familiarity can result in contagion of positive goals (Eren 2009), and provides the social regulatory foundation for effective cognitive work and collaborative learning (Volet et al. 2009). None of this is readily achievable in a large group setting with variable attendance, and suggests that increasing time and reducing group size may be helpful to our intervention efforts.

Even if supportive relationships among students could be created in large group settings through regular meetings with stable teams, there remains the issue of building students' relationships with teachers, which are often undervalued (ten Cate et al. 2011). The teacher-student relationship that develops over time is a significant factor in student learning, engagement and motivation (Hauer et al. 2012). Small group settings afford the space for communication that both enables and evolves from mutual confidence and trust between teachers and students, which in turn heavily influences the way feedback is received (Eva et al. 2010). Feedback from expert teachers is a key component of the development of self-regulation and successful remediation (Winston et al. 2012), and the provision of useful feedback requires the teacher to understand her learners, diagnose specific difficulties and offer generalizations for improvement of learning processes. However, in this intervention, critique of student learning was left to the student teams, while teachers circulated and offered occasional comments. This is problematic because students do not spontaneously produce high-level, critical discussions (Gillies 2011), and need guidance and challenges from expert facilitators to provoke them out of their comfort zones into deeper, exploratory talk (Stoyanova & Kennedy 2010; Winston et al. 2012). The careful listening that is required for such facilitation is extremely difficult in a large group situation, where many student concerns are neither raised nor challenged. Thus, we might expect the small group follow-up sessions to make more long-term difference to outcomes than the large-group workshops. The results also suggest that teacher experience matters in maintaining attendance and engagement of students, reinforcing the findings from our earlier work (Winston et al. 2012) that outcomes of remediation are significantly better for experienced than for inexperienced teachers. The implication is that trusting teacher-student and student–student relationships are an important ingredient of both successful remediation and prevention of failure, and that stable small groups may offer the most effective environment for developing these relationships.

Our results also add to the growing evidence that the practice of remediation and prevention of failure needs to account for a dose effect. Previously, we found that students who attended more than 15 ELLS sessions were twice as likely to achieve long-term success than students who attended fewer than 10 sessions (Winston et al. 2010a). Here, the maximum dose, with workshops and small group sessions combined, was just nine, and only very few students reached this. Others have similarly found that increased attendance at support programmes correlates with better outcomes (Muraskin 1997; Stegers-Jager et al. 2013), and that short programmes do not produce long-term improvements (Pell et al. 2012). Isolated, brief interventions rarely succeed (McLaughlin 2012), since behaviour change, development of critical thinking dispositions, and acquisition of new skills necessarily take time (Paul et al. 2009), requiring extended interaction with consecutive discourse and feedback in a regular environment (Dewey 1910; Kahneman 2011). A handful of meetings is clearly inadequate for fundamental change in skills and dispositions, and we would suggest that meeting twice each week for one semester would be a good place to start exploration of the most effective dose for an intervention to prevent failure in at-risk professional students.

Finally, a successful programme probably needs a systemic perspective with clear administrative support (Lieberman et al. 2010), flexible curricular options, and dedicated time for self-study, classwork, and participation in carefully designed support programmes.

Limitations and further work

Perhaps the main limitation of any research is the difficulty of accounting for complexity, and we acknowledge that since all contexts with many variables are unique, generalizations can only be tentative (Dewey 1929), particularly given the uncommon nature of our school and student population.

A further limitation is the non-random, voluntary nature of student participation, which means that motivation could be acting as a moderating variable. However, for the large group workshops, if motivation was a factor in increased attendance, it did not result in better outcomes. For the small group follow-up sessions, it may well be that motivation was a factor, but, given the differential attendance at groups led by experienced and inexperienced teachers, and that mandatory participation in our remediation course was as effective as voluntary participation (Winston et al. 2010a), improved motivation is perhaps more likely to be consequence than cause. Again, since our results for teacher experience and dose effects in this intervention are based on limited numbers, we should be cautious to generalize.

Additionally, the possible reasons for non-significant research findings can be numerous. While our discussion selects and rationalizes some likely possibilities for improving efforts at preventing failure, these ideas still need empirical verification, both in this and other contexts. We believe that continued programmatic research, testing each of the various possibilities discussed earlier, can lead to deeper understanding and improved interventions. Given these limitations, and that no grand theory of education that covers all dimensions and variations is possible (Alexander et al. 2009), we offer the following conclusions for future confirmation or refutation.

Conclusions

An exam after the first two weeks of medical school seems well-suited to our aim of finding an early predictor for our target population of students likely to struggle, confirming the notion that close similarity between predictor task and target task provides sufficient accuracy for targeted early interventions.

For prevention of failure, as with remediation, the type and details of intervention are likely to matter. Compromise solutions present serious challenges, and it is essential that systemic issues, such as workload and curricular flexibility, are addressed if we are to maximise the likelihood of successfully supporting our increasingly diverse student populations. Preventive interventions will need to be tailored for specific contexts, but it seems likely that a series of at least a dozen meetings over a minimum of one whole semester, following a flexible syllabus that teaches self-regulatory and metacognitive skills through application to content, would be necessary ingredients for success. In our own context, for example, this might involve offering a de-accelerated track to students who fail the first exam, thus providing enough time and space for attentive participation. Our results suggest that, ideally, this would happen through mandatory attendance in small stable groups led by experienced, mindful faculty facilitators, in which emotionally supportive relationships allow for sufficient academic rigour and timely constructive feedback for students to develop and apply their skills over time.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Glossary

At-risk student: An at-risk student can be defined as a student who is more likely than others to fail to graduate, either through dropout or dismissal. At-risk students' academic performance lies at the threshold or below the standards of acceptable competence as determined by the relevant institutions.
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