创新致远　聚启未来

——致远学院2019年“拔尖人才培养国际论坛”报告选编

上海交通大学致远学院　编著

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序　言

面向未来、思源致远

去年 5 月，上海交大致远学院举办了“拔尖创新人才培养国际论坛”，邀请了数位境内外知名的高等教育大师和与会的老师们分享了他们关于人才培养的经验与思考。为了将这些凝聚着智慧与哲理的经验与思考介绍给高等教育界的同行和社会，致远学院专门将论坛报告和讨论的精彩内容汇编成书。我相信，本书中的内容定能为进一步探索中国特色的拔尖创新人才培养模式提供宝贵的参考与借鉴。作为在过去十年里与全体致远人风雨同舟、上下求索的创院院长，我愿为此书作序，并将这个序言献给那些为致远学院发展做出贡献的专家、学者和所有致远人。

致远学院是在我就任交大校长之初开创的专门培养创新型拔尖人才的实验特区。当时的交大各方面的条件还很困难，尤其在基础学科领域，还处于举步维艰的局面。为了能够从根本上改变交大的局面，更加有效地为人才培养创造条件，自 2007 年开始，我就与王维克老师等交大同事们一起遍访国内外高校，寻觅志同道合的同行。我至今还历历在目的是，2008 年 7 月，当时在普林斯顿大学执教的鄂维南教授、在纽约大学克朗研究所执教的蔡申瓯教授、在马里兰大学执教的季向东教授和在威斯康星大学执教的金石教授等人与我一起多次在交大校园彻夜畅谈的场景。在沟通交流中，我们达成了一

个美好而远大的愿景：我们一起努力，在上海交大创建一个创新型拔尖人才培养的实验特区，汇聚最有创新思维的世界名师，吸引最有创新潜质的天下英才，让他们的思想在这个特区中相互碰撞、相互激励，为中国的未来培养充满创新智慧的学术大师和各行各业的领袖人才。这就是在交大人中口口相传的“致远之梦”的由来。这个愿景在校长办公会上形成了高度的共识，接着学校各部门立即以最快的速度响应，三个月后，“上海交大理科班”项目正式启动，首批学生从已经修完一年级课程的 2008 级全校各学科学生中以及 2009 级刚录取的新生中公开招生，此即后来广为流传的“致远一期”与“致远二期”的由来。为了让这些来自不同学科背景的同学站到同样的基础上，鄂维南、蔡申瓯以及交大的很多老师在酷暑中，挥汗如雨地为这些学生补课，正式开启了筑梦之路。一年多以后的 2010 年 1 月，在理科班的基础上，交大正式成立了“致远学院”，这个名字是我起的，取江学长题词中“思源致远”之意，既有交大校训“饮水思源”的精神内核，又有“宁静致远”的志向。彼时，耶鲁大学的钟伟民教授、哈佛大学的杨英姿教授、加州理工的叶乃裳教授、密西根大学 Brian Coppola 教授、德州奥斯汀大学 Lorenzo Alvisi 教授等大批有志于拔尖创新人才培养的各学科教授也已先后来到致远学院授课。写到这里，我不由想起我与图灵奖得主 John Hopcroft 教授的相识经历。自 2010 年下半年起，我就一直希望能够邀请这位享誉世界的计算机算法大师来致远学院担任计算机科学方向首席教授，但是几经试探，John 都一口回绝了我。2011 年初夏的一天，当我偶然得知 John 正在中国重庆开会的消息，并从重庆的朋友处“探听”到 John 下榻的宾馆之后，我立刻连夜飞赴重庆，当夜还给他发了一封简单的问候函。第二天早晨当 John 打开房门，知道我就是昨晚给他发过电邮的交大校长时那幅惊讶神情，我至今难忘。于是他将我让到他的房间里，就在早饭前，我向他介绍了交大与致远学院，介绍了我对发展交大计算机学科的梦想与愿景。John 非常感动，说他从中国大学校长身上，看到了中国大学为什么这么奋发，为什么发展这么快的原因，于是，当场接受了我的邀请。从 2011 年 12 月至今，这位七旬老人坚持每年来致远授

课，并持续带领一批计算机学科的国际一流专家来为致远学子和交大的计算机学科以及数学学生授课，并且以身垂范，引进人才建立了计算机科学研究中心，极大地提升了致远学院计算机科学、计算机学科和数据科学的学术影响力。我还想起了在致远学院初创最困难时，捐赠第一笔专项办学经费的上海交大继续教育学院，在致远学院设立第一笔奖学金的沈南鹏校友和后来不断给予致远多方帮助的支持的众多朋友和校友们，他们的支持为致远的初创解了燃眉之急。所有这些致远初创时期的记忆，已经成为致远人代代传承的珍贵历史，已经成为激励致远人砥砺前行的精神力量。

2010 年初，在听说交大基础学科因不满足教育部设立的拔尖人才培养基地的基本入门条件，而无法入选首批试点的消息后，我与致远的同事们都心急如焚。在我数次赴京“软磨硬泡”都无功而返的情况下，在林蕙青副部长（时任部长助理）办公室里，我咬牙立下了五年后致远学院若不能在全国各高校所有的试点项目评估中达到前三名就接受摘牌的军令状，“铁面无私”的林部长终于为交大的决心和真情所感动，破例批准交大致远学院整建制作为教育部“基础学科拔尖学生培养试验计划”的首批基地之一，在数学、物理、生命、计算机等基础学科方向开启了实验计划，致力于培养热爱科学研究，具有创新意识、理性质疑精神和社会责任感的创新型拔尖人才。自 2010 年底开始，交大致远学院才有了国家级“户口”，才有了充足的办学经费，走上了快速发展的筑梦之路。从 2014 年 9 月开始，更加富有创新精神和奉献精神的徐学敏副校长接任了致远学院院长，接力致远筑梦的第二段旅程 -“致远荣誉计划”，将致远学院拔尖创新人才的实践与经验辐射到全校。

致远十载筑梦之路，虽然历经艰辛，但是致远人所有的付出都在致远人才培养模式的初见成效和拔尖创新人才的成长中得到了最好的报答。2013 年 9 月 26 日我代表致远学院在教育部“拔尖计划”阶段性总结评审会上汇报，致远学院的教学改革和实践获得与会专家的高度赞扬；2014 年 9 月，凝聚全体致远人激情与梦想的《“致远”模式的探索与实践》荣获国家级教学成果奖一等奖；2016 年 12 月，致远学院的“好奇心驱动的主动性学习”模式在美

国费城举行的第三届全球“Reimagine Education 2016”教育创新大会上获得“Cultivating Curiosity Award（培养好奇心奖）”，和“Natural Sciences Award（自然科学学科奖）”两个奖项，由多国高等教育专家组成的评委会对交大致远模式的书面评价是：“致远学院的使命是将‘好奇心驱动的学习’的教育理念融入到‘如何促使学生的好奇心转变为有学习追求和自主创新活动’的教育教学实践中，在有效地激发学生好奇心的同时，将这种好奇心转变为学生自我发展过程中的学习动力与激励手段。致远学院营造了一个培养学生创造性思维和创新能力的良好环境”；2016 年初，致远学院开展“致远创新计划”，成立“致远创新研究中心”，由邵志锋教授领衔，设计并推动了以“致远学者研究计划”为代表的一系列促进师生互动和原始创新的本科生科研实践活动；2016 年底，致远学院计算机科学方向首席教授、图灵奖获得者 John Hopcroft 教授荣获中国政府友谊奖；2018 年底，在教育部拔尖计划十周年考评中，致远学院再次获得了全优的成绩。在徐学敏副校长的全力推动下，致远荣誉计划也进一步升级成为整个交大实施本科生荣誉计划培养的载体和主导者。

“致远模式”注重学科之间的整合、教学与科研的整合、科学与人文的整合并采取了一系列激发学生好奇心的创新举措，包括开设由名师主讲的导论课以扩展学生视野和发掘学生内在兴趣、通过贯穿四年的各种小班研讨课，培养学生提出问题和沟通交流的能力、通过本科生参与前沿科研训练激发学生创新潜质等。这些举措极大地提升了学生探究未知的好奇心和内在动力：如致远一期的谈安迪同学最初在加入致远学院前甚至想要放弃学物理，致远模式极大地激发了他对探究暗物质的好奇心，现在的他以创新为人生追求，“享受着”每年三百多天在两千多米深的地下实验室探寻暗物质的乐趣；致远四期的殷佳祺同学为了追随自己内心的兴趣，在大三结束时选择重读一年，以便从生命科学方向转到数学方向，最终以优异成绩毕业，并进入美国最好的生物统计方向攻读博士学位，这样的案例不胜枚举。

十年筑梦之路，让我感到特别欣慰的是，从致远学院走出去的 797 名学

生中有 92% 继续深造，其中 54% 在境外一流大学和研究机构，有大约 46% 的毕业生选择在国内的世界一流大学和科研机构继续攻读博士学位，这也是我当年给林蕙青副部长的另一个承诺：将尽可能多的毕业生留在国内读博。尽管致远学院从成立至今才刚过十年，但是致远一、二、三期的毕业生中大部分已取得了博士学位，许志钦、郜骋、马征、罗涛、张耀宇、毛晓军、杨笛一、鲁海昊等校友在世界一流大学担任教职，在国际学术舞台上崭露头角；还有一批毕业生取得博士学位后选择在大数据时代做弄潮儿，他们的成果已经在不同领域受到关注。假以时日，致远学院一定会培养出更多支撑未来中国高质量发展的栋梁之才，致远学院创立者们当年的梦想正在实现。

当今世界，正在经历着最深刻的快速变革，国际形势让我们更加清醒地认识到：人类社会比从前任何一个时代都更加渴求原始创新，想要成为世界主要的科学中心和思想高地，我国还需要进一步奠定创新人才基础，把培育更多拔尖创新人才作为高等教育强国的重大战略任务。2019 年 4 月，教育部“六卓越一拔尖”计划 2.0 正式启动，“拔尖计划”被定位为“仰望星空，培养未来领跑者的计划”，是瞄准“后天”，功成不必在我的计划。这标志着我国本科教育改革全面进入新时代。我们必须不断思考、不断进步、不断创新，才能让致远学子可以从容不迫地面对未来的科技革命和国际竞争。

致远学院举办“拔尖创新人才培养国际论坛”的初衷就在于为拔尖创新人才培养而共同努力的教育者们提供一次共享经验、推进改革的平台，让论坛上的精彩报告在更大的范围启迪出更多深入思考，碰撞出更多智慧火花。

在这次论坛上，有 9 位国内外知名高等教育专家做了主题演讲，他们每一位都在基础学科研究领域有着很深的学术造诣，对拔尖人才成长和培养也都有着自身独到的见解与实践。这里，我仅以三个报告为例。图灵奖得主、康奈尔大学 John Hopcroft 教授曾经培养出十余位美国科学院和工程院院士，是一位名副其实的大教育家。他认为，对学生成长至关重要的因素是教师应当关注学生的成功，教师做前沿科研的根本原因在于保持自己的教学跟上时代。这就完美诠释了为什么 80 多岁的他依然活跃在学术最前沿，每年发表

论文和学术演讲。Jeffrey Lehman 教授是上海纽约大学美方校长，曾获得中国政府友谊奖，2018 年获评“改革开放 40 周年最具影响力的外国专家”。他深刻阐释了在全球化和人工智能时代的双重冲击下，以熟练、高效、富有同情心的方式与其他文化中的人进行交流的重要性，这已经成为下一个十年本科生需要具有的六种基本技能之一。这不仅适用于历史学家和诗人，对于计算机科学家、自然科学家和数学家同样适用。如何对具有创新潜质的拔尖人才进行科学选拔一直是致远学院不懈探索的命题。美国化学学会会士、密西根大学化学系教学副系主任 Brian Coppola 认为，识别人才像一门艺术，无法仅仅通过测试来实现，识才需要高度主观决定，可以具有个人偏好。他建议从通过提供学习者、个体人、创造者以及领导者的经历，观察学生在这当中的行为和特质，以此作为识别有天赋学生的标准。他直言不讳地指出，中国大学没有发挥学生在学科知识储备方面的优势，很多导论课只是重复以往的知识，课程数量也太多，学生缺乏自主思考的时间。可以说，此次论坛的 9 场主题报告浓缩了当下国内外高等教育大师们的宝贵见地与经验，对我国下一个十年更好开展拔尖人才培养提供了极富价值的指导意见。

回顾过去，致远的理念与实践已经是致远学院成为创新人才的沃土。面向未来，希望致远能够在下一个十年中进行更具挑战的探索与实践。面向新的科技革命时代，在我看来，创新人才必须重构物质科学、生命科学、数据科学、人文科学的四大知识结构群，这不仅是未来知识体系的主干，更为拔尖人才思考自然、社会、政治、经济等问题的基本出发点提供重要支撑。这就需要我们加大力气探索学科交叉融合、注重思想方法的通识教育。

通识教育是培养全人的一个重要途径。面向快速变化的未来，各国高等教育专家都在探索对通识教育的深度改革，对于我们中国高校来说，这个需求更加迫切。通识教育的本质并不是教学生思考什么，而是要培养学生如何思考，掌握正确的理性思维方法。在过去的十年里，致远学院主要探索了如何加强专业基础教育，致远学院的未来十年里，将会在通识教育方面进行根本性改革。一流的通识教育与一流的专业基础教育的结合一定会进一步提升

致远学院的办学水平。我希望不久的将来能举办一次以通识教育为主题的国际论坛，深入探索适合快速变化的未来要求的通识教育模式。

衷心希望致远学院下一个十年的拔尖创新人才培养继续坚持以“好奇心驱动”为中心的理念，不断求索，不断实践。期待致远学院能够通过培养大批拔尖创新人才的伟业，为交大的未来、中国的未来、乃至人类的未来作重要贡献。

感谢所有与我们一起为梦想而努力奋斗的人！

张杰

2020 年 6 月

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一、领导致辞

创新拔尖人才培养 引领未来教育方向

——在2019年上海交通大学致远学院“拔尖学生培养国际论坛”上的讲话

上海交通大学副校长 奚立峰

尊敬的各位嘉宾、各位专家：

大家上午好！

今天，很高兴能和大家相聚在上海，共同参加由上海交通大学致远学院主办的“拔尖学生培养国际论坛”。首先我谨代表上海交通大学向到场的各位专家们和兄弟院校的同仁们表示热烈的欢迎，向长期以来关心和支持上海交通大学发展的各位朋友们表示衷心的感谢！

“培养第一等人才”一直是上海交通大学坚守的传统使命和教育目标。2009年，上海交大依托学校的工科优势加大理科和工科结合的力度，培养基础学科领域的领军人才。此后在教育部“基础学科拔尖学生培养计划”（简称“拔尖计划”）的支持下，专门成立致远学院，培养能够引领中国经济社会发展和世界科技进步的创新型领袖人才。2014年开始，学校依托致远学院，以“致远荣誉计划”为载体，将培养范围拓展到工科和医科方向，努力让全校范围内“真正以投身科学研究为人生最大价值追求”的优秀学生获得更好的发展机会。近年来学校还专门启动实施博士生“致远荣誉计划”，着力打造“本科-研究生贯通”的拔尖人才生态链。

十年来，致远学院逐步打造形成了交大特色的“好奇心驱动”的拔尖人

才培养体系，得到了以图灵奖得主 John Hopcroft 教授为代表的一批国际学术大师的鼎力支持。致远学院培养的毕业生学术志向坚定、专业兴趣浓厚，迄今为止七届 618 名毕业生中有 91% 选择继续深造，62% 选择攻读博士学位，一批学生已经开始在国际科学舞台上崭露头角，显现出未来科学家的潜质。与此同时，致远学院作为学校拔尖人才培养的特区，在营造全校崇尚学术的本科教学氛围、引领全校本科教育教学改革、提升全校整体人才培养质量等方面发挥了积极的示范和辐射作用，并促进了学校相关学科建设和师资队伍建设。

当前，世界正处于大发展大变革时代，人类在全球化进程中共同面临着环境、能源、安全等一系列重大复杂的问题和挑战，新一轮科技革命和产业变革扑面而来，给人们的生产、生活、学习和思维方式都带来了全新甚至颠覆性的影响。教育决定了人类的现在和未来，拔尖人才处于人才金字塔的顶端，是科技发展和人类进步的重要力量。因此，我们需要重新审视当下拔尖人才培养的定位和作用，以相互包容、尊重差异、多元发展、合作共赢的心态，继续探寻创新人才成长规律，创新拔尖人才培养模式，引领未来教育方向，共同推动人类文明进步和世界和平发展。

拔尖人才培养需要一套特殊的教育体系，与其说“培养”，更准确的不如说是培育和熏陶。只有个体本身对事物真正感兴趣甚至是热爱和痴迷，并得到学者型教师潜移默化的影响，才能成就真正的拔尖人才。为此，我们做了大量的前期调研工作，在吸收和融合中西方书院文化精髓的基础上，启动了致远荣誉书院建设规划。目前，正在积极打造师生共学共研共融的学习生活共同体；以致远 FELLOW 体系为抓手，引进和建立致远专属“教师团队”和“导师团队”；“教书”与“育人”并重，推进通识教育改革，持续地支持致远学院打造“好奇心驱动”培养模式的 2.0 版。今天来参加本次论坛的嘉宾，有“拔尖计划”试点高校及相关高校的代表们，也有境内外高等教育领域的管理者和研究者。在一个月前召开的“六卓越一拔尖”计划 2.0 启动大会上，教育部提出了建设基础学科拔尖学生培养一流基地的核心任务，为我们下一

步工作指明了方向。我想大家和我们一样，都在思考接下来“拔尖计划”进入2.0阶段，面对新的挑战和诉求，高校应当如何担当起培养引领未来的拔尖创新人才的重任。

我想，不同文化、不同历史背景下的创新人才培养各具特色、优势各异，不过培养具有强烈的社会责任感、卓越的学术能力和终身学习能力的拔尖人才是我们教育工作者的共同追求和努力方向。增进境内外交流与合作是大学提升拔尖人才培养质量，开拓新思路，寻求新方法，启发新思考的有效途径。我相信本次论坛一定能够为大家搭建一个交流情感、传播思想、分享智慧、资源共享的平台，真诚希望各位专家学者各抒己见，充分交流，分享彼此对该议题的深邃思考和实践经验，为之注入新的思想和活力，共同推动全球创新人才培养的纵深发展和长足进步。

最后预祝本次论坛取得圆满成功！祝愿大家在交大度过愉快美好的一天！谢谢大家！

论坛闭幕致辞

上海交通大学副校长、致远学院院长　徐学敏

老师们、同学们，以及到场的各位嘉宾，大家下午好！今天的拔尖人才培养国际会议信息量很大，相信每一位参会者都与我一样，深感受益匪浅。首先，请让我们大家再一次以热烈的掌声感谢所有嘉宾的精彩演讲！

今天的报告内容极其丰富，不仅在区域上跨越了几大洲呈现了世界不同区域的优质教育资源在拔尖人才培养方面的实践与特色，而且还从时间的跨度上，阐明了教育的本质在于推动人类社会进步。特别是瑞典 KTH Ramon 副校长通过工程教育发展的历史沿革，充分展示了“挑战驱动”在教育中的重要性。美国康奈尔大学 John Hopcroft 教授提到如何让老师们走进课堂，教好每一门课；如何选拔学生，让学生更好进入研究实验室，体现了以“兴趣导向”来激发师生互动、相互学习的教育理念。

众所周知，这是一个信息爆炸的时代。在教室里，在有限的时间段内，我们能够传授给学生的知识只是冰山之一角。我们需要注重学生的能力培养，特别是他们终身自主学习的能力。今天的拔尖人才培养国际论坛是一场盛宴，它从世界的各个维度来剖析教育的本质。有专家的亲身实践，还有从专门研究教育的资深专家的分享，并通过深层次的思想碰撞，激发火花，形成一些共识。相信在未来的具体实践中，我们每个人都会从不同的角度去找到它的答案。

当今世界，风起云涌。人类不仅面临许多自然的挑战，而且还存在着许多复杂的社会问题，需要我们共同努力去解决。互联网可以将世界上每个角落的每一个人都实时连接起来，我们没有办法忽略任何一个地区、任何一种文化。今天的教育需要更加的开放，要学会理解和尊重不同文化体系，文明相鉴。只有这样，我们才能够携手，拥有一个共同努力的目标，即培养推动人类社会进步，创造未来的引领性人才。这正是培养拔尖人才的使命，不仅仅是中国的，也是世界的。

为了人类的美好未来，提升人类智慧和创造未来的潜力是教育的本质。它从来没有改变过，未来也不会有所更改。这就是我们今天相聚在此的目的。希望今天的论坛能够成为我们拔尖人才培养交流新一轮启动的标志。教师的交流推动学生的交流，我们共同引导学生进入不同的学习环境，感受不同的科研领域，体验不同的文化。学生的流动可以在我们拔尖基地间，也可以通过国际合作伙伴学校到世界的各个角落。相信他们终将拥有开阔的视野，成为能够拥抱整个世界的创新人才，成为人类命运体系的构建者。

最后，我想再次感谢各位来宾的支持，特别是远道而来的演讲嘉宾，以及全国拔尖人才培养基地的辛勤工作者，同时也要感谢致远学院为筹备这次论坛所做出的努力。希望大家在上海过得愉快。谢谢！

二、主题报告（中文）

机会与成就：本科拔尖人才培养路径之思考

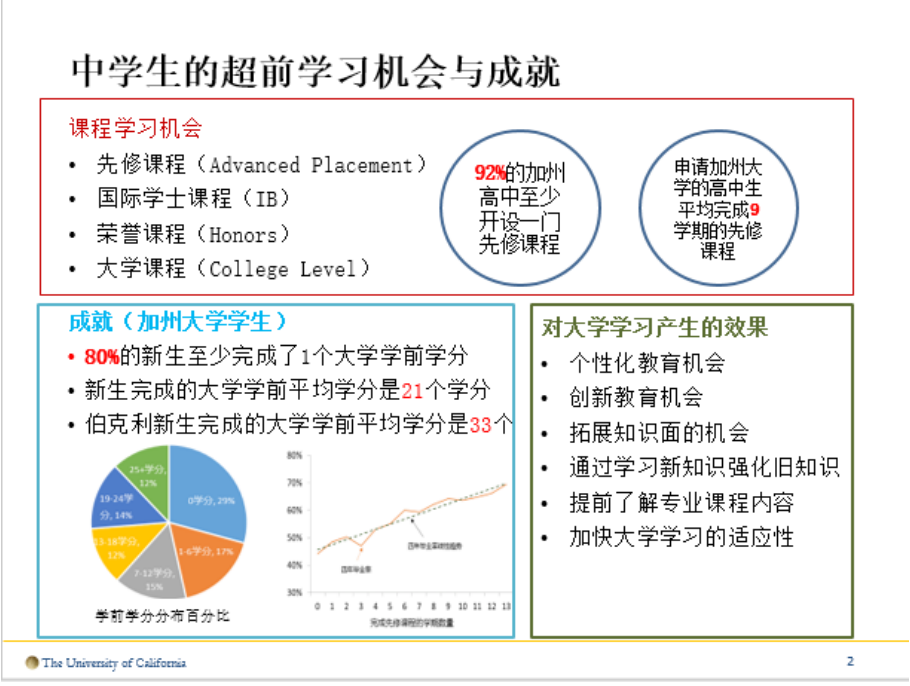
加州大学校长办公室院校研究与学术规划主任 常桐善

尊敬的各位嘉宾，大家上午好！非常荣幸有这次机会能和各位学者交流。我此次汇报的题目是机会与成就，我今天想从这个角度来谈一下我对拔尖人才培养的思考。

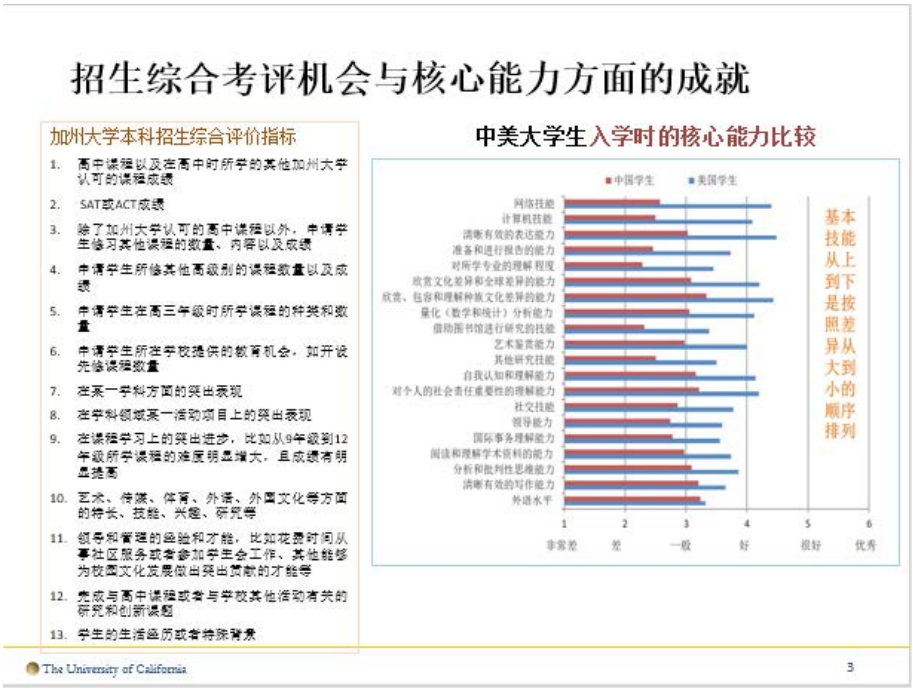
当我最初收到国际论坛的邀请时，我并不知道我要汇报什么内容。就我自己而言，我没有读完小学，在我初中毕业之后，我也没能考上高中，但是我非常高兴有机会上了大学，更高兴的是有机会赴美国的波士顿进行深造。在美国波士顿期间，我非常感谢我的母校给了我许多学习的机会。虽然我的学校不是排名很靠前、很有名的大学，但是学校提供了各种各样的学习机会。我在读博士期间学习了计算机方面的课程，同时我也读过统计学方面的课程，我觉得这些机会难得，对我的发展非常有益。即便我本身并没有取得什么成就，但是至少我自己感觉到这些机会对我的成长以及我现在在加州大学从事的工作都有很大的帮助。所以今天我想以我在加州大学所研究的数据，当然更多的是关于学术数据，以及成长数据来谈谈机会与成就之间的关系。

第一个方面是关于中学生的超前学习机会与成就。众所周知，中学生的大学学习经验有一个过渡期和适应期，美国的中学为学生提供了很多过渡期课程，比如说：先修课程、国际学士课程、荣誉课程以及大学课程。这些课程让学生提前了解了大学的教学方法，对今后学生的大学生活是很有帮助的。

比如说，加州有 92% 的高中至少要开设一门先修课程，在申请加州大学的学生中，完成的平均先修课程是 9 个学期。学生进入加州大学以后，70% 的新生至少完成了 1 个大学学前学分，完成的平均大学学分是 21 个学分，在伯克利的学生学分更高，平均是 33 个学分。33 个学分意味着一个学年的学习学分，但是这些学分并不一定被大学认可。但学生通过完成这些学分，会对大学的教育有一个比较清楚的了解。下述饼形图展示了学生完成学前学分的一个分布状况。大家会看到一个正相关，完成的学前学分越多，大学的毕业率是越高的。所以说，完成这些课程，不仅帮助学生缩短了适应期，更重要的是为学生提供了科学化的学习教育机会，同时也提供了创新教育的机会，并拓展了学生的知识面，通过学习这些课程丰富了不同的专业领域知识。中学生的超前学习机会对学生的发展和拔尖人才的培养是非常重要的，因为有的学生精力旺盛，他在高中阶段，除了学习正常的课程以外，他完全有精力学习先修课程。



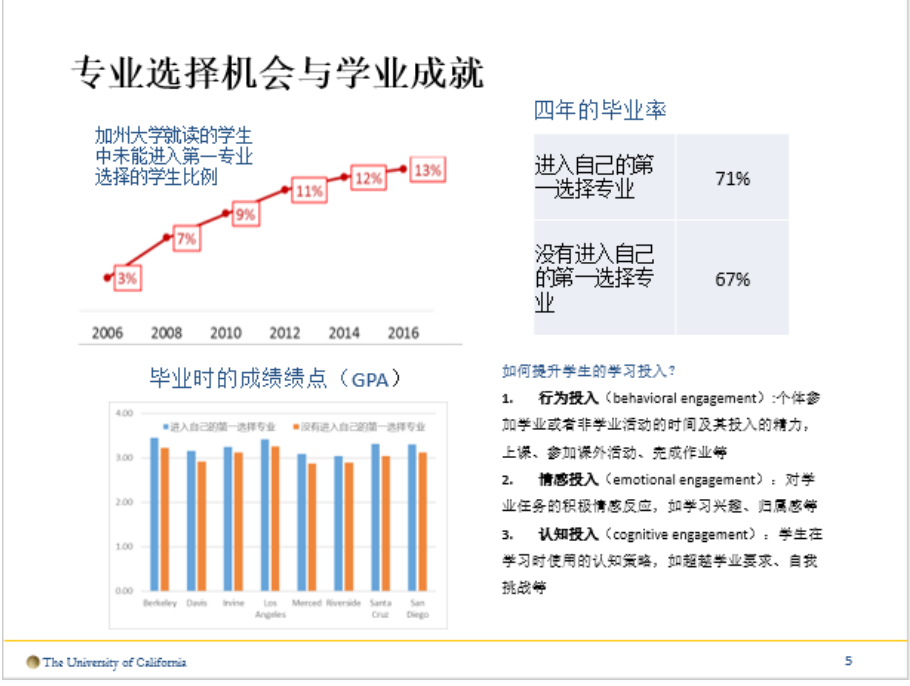
第二个方面是有关大学招生的综合评价，也就是学生核心能力的发展。我们现在的时代对学生核心能力的要求是越来越高的，我们的成就、成功与学生的核心能力机会的关系也是越来越紧密的。学生的学习和学生的培养不要输在起跑线上。我认为，就大学培养学生的核心能力来说，大学的评价和综合考核的招生就是培养学生的一个起跑线。所以美国的综合性大学在本科招生的时候，都会对学生的能力和学生的知识性进行评价。我在这张幻灯片上列出了加州大学本科招生综合评价的指标，包括学生的成绩、学生完成的课程、以及学生各方面的能力。



右表显示了学生入学时在软性能力方面的一个情况。这个程度是非常差到优秀，大概包括 20 多项的指标：有网络技能、计算机能力、清晰有效的表达能力等。我们利用这个工具和国内的四所大学进行了合作，蓝色代表美国的学生，红色代表中国的学生，大家可以看到差距还是非常大的，特别是在第一项和第二项。这个排序是按照差距的大小，由大到小依次进行排序的。

如图所示，网络技能方面差距非常大。在我们调查时，有的学生已经进入了大二、大三、大四的学习，但这些指标的差异性仍然是非常明显的。

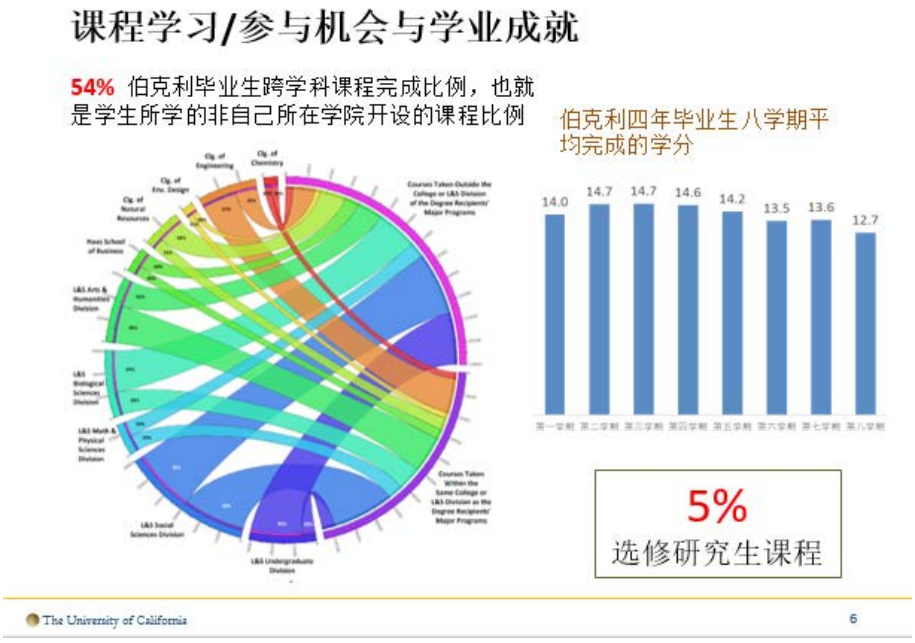
第三个方面，我想讲一下专业选择机会与学业成就。就学生的投入而言，根据美国的几位学者研究，我们可以从三个方面对学生投入进行分析。第一个是行为投入、第二个是情感投入、第三个是认知投入。情感投入，它涉及到学生的学习兴趣，学生对所学专业以及对学校的归属感；认知投入是指学生对自己的主观挑战度，比如说选择哪种课程的挑战能力。情感投入和认知投入都是与学生能否进入感兴趣的专业有直接关系。他能有兴趣吗？他能有归属感吗？他能有自我挑战的能力吗？上方的条形图展示了加州大学伯克利学生的数据情况。



他选择的是不是他的第一专业？在 2006 年我们统计的数据显示 97% 的学生就读的专业是他的第一专业，也就是他最想上的专业。当然这个比例在逐年的下降，到了 2018 年的时候，这个比例降到了 87%。它是一个下降的

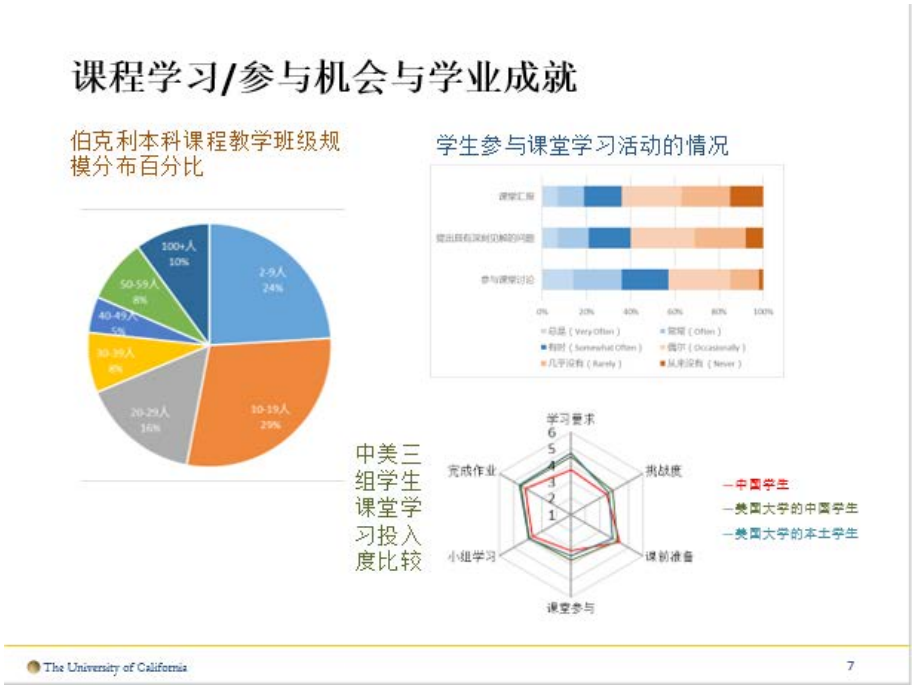
趋势，但是这个比例仍然是比较高的。左上角的这个图展示了他所选专业与他所完成学业的关系。如果他进入的专业不是他的第一专业，那么他毕业时的成绩（毕业率）是 67%，这个差别不是很大。左边的这个图展示了加州大学几所本科学校进入第一专业的学生和没有进入第一专业的学生的 GPA 比较。大家可以看到，蓝色条状图代表能够进入第一专业的学生，他们毕业时的 GPA 是普遍高于没有进入第一专业的学生的。这个差距大概是 0.3 - 0.5。因为 GPA 的成绩，4 是最高的，所以 0.3 - 0.5 这个差距还是很大的。所以，在我们从事本科学生拔尖人才培养工作的时候，我们也在考虑我们是否可以为学生提供他们感兴趣的专业。

课程学习与参与机会。课程学习是提高教学质量最重要的一个方面。如果课程学习和课程锻炼不能满足学生的学习需求，那么同样会对学生的成长和对学生学习的反省造成很大的影响。就加州大学伯克利分校来看，从课程设置和学生学习课程的组成来说，54% 是与他们所学专业非相关的学习课程，在这里面包括了一些通识教育。在加州大学，一般的通识教育占比 1/3，



通识教育以外的很多课程，也是从其它的专业中选取来开设的课程。这个表格展示了学生选择的课程有多少是在自己领域中开设的课程，多少课程是其它学域中开设的课程。很显然，其它学域中开设的课程和它的专业可能有关系，但是却是其它领域的课程。这样的课程设置对拓展学生知识领域是非常重要的，跨学科对学科创新的影响是非常大的。100 年以前，加州大学伯克利是最早提出跨学科学习的，团队是由跨学科不同专业背景的学者组成的。在大约 100 年以后，我们不敢提倡跨学科学习，我们学校是不是为学生提供了一个这样的学习氛围，提供了机会。右边的条形图是展示了加州大学伯克利的学生四年毕业生八学期平均完成的学分。

为什么要做这个分析呢？我一直参与本科教育史的工作，在学科教学中，我常常听到学生说，他们的课程都是在大一、大二集中学习，每个学期要学 12 门课程，也就是 24 或者 25 个学分。我们大致做个计算，24 - 25 学分要求学生每一天都要投入，他们每天要花费多少时间才能完成？如果他这个时间花的不够，那么他的学习质量肯定是要缩水的。我们大致计算了一下，如果一个学生一个学期大致要上 12 门课，按 25 个学分计算，他一定是有一部分学分是打了很高的成绩，其它的并没有花足够的时间去学习。这段时间我写了一篇文章，说能学 12 门课的学生，他怎么能完成呢？所以这是我们要着重思考的一个问题。右下方展示了加州大学伯克利分校春季学期本科学生学习研究生课程的一个比例，其中有 5% 的学生在上研究生的课程。这些学生是否以后会成为研究生呢？也不一定，但他有这个机会在本科时期学习研究生的课程，从他知识的组成来说，他已经在一定程度上超前于和他一起进入学校的其它本科学生，这也是一个机会，学校是否能提供这个机会？



关于课程学习，上述饼状图展示了伯克利规模分布的一个状况，2-9 人占 24%，10-19 人是 29%，这两项加起来超过了一半。小班级教学，它有利于学生的互动，有利于学生的讨论。怎样让学生投入到教学过程中去，我们是不是能从班级的规模入手，当然老师的教学方法也是很重要的，我们是不是可以提供一个小班教学的条件。上图展示了学生参与课程学习活动的情况，包括课堂汇报、提出具有深刻见解的问题、参与课堂讨论，蓝色部分是有时、总时或者常常，红色部分是不常，这个比例事实上不是很好，基本上大约有一半的学生在上课过程中能够积极的参与到教学当中去，在这些指标上还是有很大的区别的。下面是新做的一个比较，中美三组学生课堂学习投入度比较，我分成了三组。一是中国大学的学生，刚才提到的有四所大学合作和我们做这方面的研究；绿色是美国大学的中国学生，就是我们说的国内高中毕业去到加州大学上学的学生；下面蓝色的是美国大学的本土学生。学习维度、挑战度、课前准备、课堂参与、小组学习，完成作业，共六个维度。

在课前准备维度方面，我们中国大学的学生是优于美国本土学生和美国大学的中国学生的。在其它几个维度上，特别是在学习要求维度上差距很大，学习要求是根据父母教育的分类来调查得到的数据，然后综合计算因子结果来进行展示。老师上课对学生的学习要求还是应用风险的事情，所以在这几个维度差别上不是很大。当然很多的原因造成了这个结果，但是我们通过教学的课堂规模以及课堂上老师的教学方法对学生参与的要求都是造成在这些维度上差异的原因之一。

这张幻灯片展示了六个百分比。这六个百分比都与学生的实践工作和参与研究的机会有直接关系。第一个 23% 是指在所有的教学和科研人员中（包括教学和研究助理）担任教学或者研究助理的学生所占的比例。也就是说在加州大学所有的 9 所本科教学学校中有 23% 的教学和研究助理是由学生担任的。这个比例还是非常高的，也就是说学生（包括本科生和研究生）有很多的机会参与到教学工作中。在伯克利这个比例会更高，有 32%。也就是说我

们按照全职的教职人员来计算，是由 32% 的学生来完成这项工作的。可想而知，学生通过这些锻炼，他们的成长，他们实践能力的提升是非常重要的。第三个 9% 是指在所有服务和行政人员中，学生工作人员所占的比例。在加州大学 15 万的行政服务人员中，有 9% 的工作是由学生来完成的。也就是说大学校园给学生提供了很多的工作机会。初步的估算，有 15% 的学生不同程度的参与了一份工作。我们做了一项研究，在加州大学毕业的学生中，有 40% 获得学士学位的学生曾经和教师一同完成老师的研究项目，这个比例还是非常高的。当然（与）类似于斯坦福的其它私立大学，比如康奈尔（相比），这个比例还是比较低的。据我所知，斯坦福 90% 的学生都参加过老师的研究项目。当然我指的这个研究项目不是毕业设计，而是参与到老师的研究项目之中去，和老师一同从事一项工作，这个比例是非常高的。那么我们也迎来了一个问题，在大学本科期间参加过教师研究项目的学生获得博士学位的比例是没有参加过研究项目的学生的 200%，也就是两倍。他们更有可能获得 PhD，当然这个也许是他们想要读研究生或者想要从事一个工作而去找参与老师研究项目的一个机会。不管怎么说，他有这个想法对他未来的研究工作是有很大的帮助的。

加州大学也会提供荣誉课程给一些拔尖的学生。伯克利电子工程和计算机科学专业的荣誉课程申请要求和毕业要求的标准并不是特别高。比如入学的时候，GPA 要求是 3.7，但毕业的时候 GPA 要求是 3.5。当然也有一些跨学科学习的要求，在专业以外的高年级学习课程必须要达到 10 学分，所以说这对跨学科学习的要求是非常高的。

以上利用一些数据对学生的学习机会和成就做了一些简单的阐述，接下来是一些总结与思考。第一个思考是如何对待拔尖人才培养之后的大概率与小概率的问题。作为学校，我们是否应该努力给所有的、或者是大多数的有能力的学生来提供学习的机会？以更多的学生去创造成才的条件，还是仅仅以少部分我们所认为的他有潜力的学生去提供机会让他们去成功？这是一个特别值得去思考的问题。从刚才的数据来看，从刚开始的起步，我们的机会

没有提供给所有的学生，但是随着学生加入到荣誉课程中，我们会为一些拥有更高成就的学生创造机会。如果就成功的可能性来说，前者成功的概率比较小，后者成功的概率比较大。但是也有一种可能，小概率产生的结果可能大于大概率产生的结果。因为基数比较大，虽然成功的概率小，但是最终成功的人数可能会多。这是我们值得思考的问题，也是值得在完善荣誉课程的时候值得思考的问题。

第二个值得思考的问题就是创造理论学习与实践学习相结合的机会问题，这也是我们值得思考的一个问题。简单地说，就是如何向课程学习和实践学习要知识，要能力。理论学习和实践学习相结合所取得的成果应该是大于课程学习成果和实践学习成果之和。在课程教学过程中，从答疑开始，在学习学术课程知识的同时让学生有机会来参加实践活动，这样课程学习和教学是互相融合的。这种成果可能大于让学生集中精力在大一、大二、大三学习课程，到了大四再去参加实践的这个成果的。在参与一所大学本科教学审核的时候，有一位大四的学生主动提出了要和我交谈一下。这位学生临近毕业，刚刚从四川回来，专业是发动机制造。他从四川回来的感触很深，在大一、大二的时候，每个学生都学 12 或者 13 门课程，根本没有时间去想这个发动机是如何制造的，虽然学习了很多课程，但他仍然不知道发动机制造的原理以及操作的具体内容。直到大四的第二个学期，他从四川实习回来之后豁然开朗。他说如果当时有机会去到这个基地去实习，哪怕是一个月，哪怕是一周，那么我的大学生活都会完全不一样。他非常的遗憾。所以我这里的数学公式表达就是：课程学习与实践学习相结合的成果 > 课程学习 + 实践学习。

第三个考虑是如何加强拔尖人才的综合素质、基本能力和跨学科知识培养的问题。这个问题与我们如何界定拔尖人才有直接的关系，也对拔尖人才培养，甚至是大学的整体教育都有导向性作用。同时也会对基础教育的培养模式产生影响。拔尖人才的培养一定要结合基本能力、专业领域能力和跨学科领域能力，缺少其中一项，都可能会出现问题。

（译者：赵舜娜吉）

培养本科生多元文化有效性：为何及如何

上海纽约大学美方校长，原美国康奈尔大学校长 Jeffrey S. Lehman

很高兴今天能在这个论坛发言，论坛的主题是我一直非常感兴趣的话题——培养本科生竞争力。我将围绕有关竞争力的一个特殊维度来阐述我的观点，即多元文化有效性。

今天上午我的发言将主要围绕以下两点：

- 为什么我们认为大学应当关注学生的多元文化有效性，以及一所大学如何能够成功培养学生的多元文化有效性。

首先，我想谈谈为什么大学应当关注学生的多元文化有效性？

几年前，Lynda Gratton 和 Andrew Scott 合作写了一本畅销书——《百岁人生：长寿时代的生活和工作》(The 100-Year Life: Living and Working in an Age of Longevity) (2016)。

这本书主要呈现了单纯的人口统计数据。如果你到网上查找“人类死亡数据库”，你会发现 19 世纪早期的数据来自一部分国家，而 20 世纪早期的数据则来自另一部分国家。最早的那些数据来自欧洲国家，主要有比利时、英国、法国、荷兰、挪威和瑞典。在大约近两个世纪时间里，这些国家人们的预期寿命每十年平稳增长 2.5 到 3 年。

在那些国家，所谓预期寿命的“长度估算”从 1840 年的 45 岁左右提升到 2000 年的 85 岁。20 世纪的数据来源国家中，寿命长度的提升节奏几乎是

一样的。如果你用“队列估算”（即考虑到技术和社会进步带来的每一岁年龄里死亡率的降低）而非“长度估算”的话，那么推论现在出生在富裕家庭的孩子寿命达到 100 岁都是合理的。

Gratton 和 Scott 提出了一些缜密而大胆的观点，有关三阶段生命模型即教育、工作和退休已经不再适用，人们应当如何规划五阶段生命，即每个阶段会在不同时间发生，对不同人而言顺序也不尽相同。如果大学不能预见到自己的毕业生人到中年后会返回学校学习，那会如何呢？因此，我们有道义上的责任来问问我们自己，如何教育学生在毕业后 80 年如何还能有更好的人生。

Gratton 和 Scott 还提到，如果人们要在科技加速发展的时代里生活的更长久，在某些特定时刻会发现自己早年获得的特殊技能已经过时。因此，他们认为，“在工作生涯，人们在某个阶段会选择习得某种特殊技能，但在进入另一个智力领域和活动时，他们需要重新习得另一种特殊技能。这就导致正规教育需要不断创造机遇来培养基本的分析能力和分析准则。基于这些基础，教育还要再创造机遇让学生具备灵活性和创新性，以及跨学科能力。”

Gratton 和 Scott 强调的“基本分析能力和分析准则”与其他作者强调的观点不谋而合，即在机器被赋予越来越强大的人工智能形式的世界里，如何更好的让学生做好准备。

有关这个话题，我由衷地推荐一本书——《机器、平台、大众》(Machine, Platform, Crowd)，作者是 Andrew McAfee 和 Erik Brynjolffson。这本书探索了技术、经济和社会行为之间的关系在过去十年里的转变，以及下一个十年这一关系将如何继续转变。

作者很好地解释了为何人工智能的发展通过消除人们从事常规工作的需求进而改变人类文明。被消除的不仅是常规的体力工作，还包括常规分析类型的工作。即将到来的智能机器时代将与我们今天习惯生活的世界有显著不同。

作者提出智能机器时代可以被称为“有益的人工智能”时代，但如果人

们希望继续保持创造性，他们需要能够从事机器无法实现的更重要的、非常规的工作。他们需要懂得如何指导智能机器在社会生产性领域工作，还需要具备“社交技能”，以熟练、高效、富有同情心的方式和他人互动。这不仅适用于历史学家和诗人，对于计算机科学家、自然科学家、数学家同样适用。

然而，无论是 Gratton 和 Scott 还是 McAfee 和 Brynjolffson 都没有详细阐述什么是基本技能，什么是关键的社交技能，以及应该如何习得这些技能。我一直在思考这个问题。我个人认为以下六种技能应该被强调：

1. 算法思维
2. 批判性分析
3. 创造性
4. 社会感知性
5. 说服能力，以及
6. 多元文化有效性

在其他场合的报告中，我阐述过前五种技能。今天，我想着重讨论多元文化有效性。

在我小时候，多元文化有效性压根得不到人们的重视。当我和我的同龄人开始进入大学时，我们能想到的是自己的大学生活将和那些与我们几乎一样的人们在一起度过。作为一个美国人，我能想到的就是和美国人在一起，我的中国伙伴期待的就是和中国人在一起，而法国伙伴则和法国人在一起。

今天，这个世界已然不同。我们所有人的生活和工作都需要持续不断地与那些和我们成长于完全不同的文化里的人进行互动。几年前，很多人认同这样的说法，我们生活在一个全球化时代。我想用“趋同时代”来描述这个特征。各种跨越边界的潮流加速发展，不仅是物品、服务、资金的跨越边界，更包括观念、文化联系、对话、合作、认同、友情、对世界的强烈愿望等的跨越融合。

瑞士苏黎世联邦理工学院研发了一种名为 KOF 指标的方法来定量测量全球化，主要测量经济、社会、政治维度方面的全球化。从 1970 年到 2015

年，KOF 指标体现了全球化各种形式的迅猛增长。

有些令人意外的是，从 2015 年起这种全球化增长模式暂停了。根据 KOF 指标，2015 年之后贸易一体化和文化全球化进程实际上反而在退步，社会全球化程度只是略微增长。

尽管破坏性民族主义的兴起会导致如今关于全球趋同的言论听起来不再那么有说服力，但我们不应当就此夸大全球化进程的衰退。我毫不怀疑，作为多元文化团队里的一员，今天的学生们将终生以多元文化团队中一员的身份活跃地生活。

我想说的是全球化进程的放慢仅仅反映国家壁垒仍然存在。因为在中国生活与在韩国生活肯定不同，与在朝鲜、在印度、在日本生活也不同。

不同的国家选择了各自不同的政治和经济制度。这些选择对人们每天的生活都产生了深远影响。重要的是，这些不同之处也体现在语言与文化系统的差异中。尽管最重要的价值观是普世的，比如爱、尊重、诚实、信任，但不同文化传统形成了人们日常表达价值观和态度的不同方式。人们被教育用这些不同方式与所处的世界建立联系。

一个非常有趣的心理学文献记录，有着相同生物特征的孩子在不同的文化模式中成长是如何建立起不同的认知模式的。孩子们觉察事物的方式不同，分析事物的方式也不同，原因在于他们对这些问题所习得的答案不同：“什么是有影响的？什么是更重要？”。

大约 15 年前，对这个研究领域的兴趣随着 Richard Nisbett 所著的《思维的版图》（The Geography of Thought）一书的出版而得到提升。这本书充满了来自严格心理学实验的实例，非常有趣。尽管存在被批评过于简单化的风险，这些实例支持了以下观点：在人们对世界的观察中，在亚洲文化长大的人更倾向于有意识地关注一个事物与它所在环境的联系；而在西方文化长大的人更加有意识关注的是，如果一个事物所处环境发生变化，它的哪些特征却不会随之发生改变。

两年前，另一本有重要意义的书出版了，作者是一位叫 Gish Jen（任碧

莲）的女士，她被很多人称为“伟大的美国小说家”。她出生于美国，父母在中国长大，这赋予她具备深刻文化差异理解的能力。在她的新书《行李认领处的女孩：东西方文化差异》（The Girl at the Baggage Claim: Explaining the East-West Culture Gap）中，她讨论了西方社会如何培养一种强调独立和有明显边界的自我意识，而东方社会则培养了一种相互依存、模糊边界的自我意识。

最重要的是，Jen 认为当东西方人频繁互动时，他们需要养成一种特别的技能。她将这个技能形容为“贯穿于相互依存的独立性”，她称之为为“矛盾依赖性”。

有矛盾依赖性的人往往具备一种技能，诗人 John Keats 称之为“负面能力”。这种能力可以在他们脑海中同时产生两个相互矛盾的想法，无需着急判断哪个正确，哪个错误。他们可以识别出两个人产生误解的场合，因为他们能透过不同的文化角度看待事物，还可以帮助这些人从更细致、更复杂的角度去理解这些状况。他们是具备跨文化有效性的高手。

有矛盾依赖性的人认同全球性的见解，哲学家 Anthony Appiah 定义为“普遍主义”与“尊重差异性”的一种健康混合。具有这种全球感知的人们认为自己与那些不同文化背景的人一样，是同一个精神世界的不同组成部分，他们认为，一些基本的道德责任是普世的。与此同时，他们认同一种谦逊，对人们自主决定能力的尊重。如果一些文化特征相比普世价值观并不那么重要的话，他们不会试图把自己文化的特征强加给别人。

因此，大学如何采取举措帮助学生成为具备多元文化有效性、“矛盾依赖共存”的世界性高手？

毫无疑问，有很多种方式来开展这一任务。在上海纽约大学，我们采取了一种核心方式来实践，我认为我们也取得了相当的成效。我接下来介绍我们学校的这一做法。

我们学校有个特征在于架构性，它必须适用我们学生群体的构成。

我想指出，历史上，无论中国大学还是西方大学都没有注重培育过世界

性人才。事实上，几乎所有大学都更注重发展本国文化。几乎所有大学都有至少 75% 的学生来自本国。大学只是期待国际学生学会如何适应本土文化，而完全不去考虑本土学生应该如何与外国学生建立密切联系。

从这个角度来看，上海纽约大学敢于创新。我们有一半学生来自中国，另一半学生来自超过 80 个国家。在安排宿舍时，每个中国学生都会有一个外国室友，每个外国学生也都有一个中国室友。

我们的教员构成也反映了不同寻常的国籍多样化和世界性程度。教员们来自 25 个不同国家，他们几乎都有在各自祖国之外的国家工作和生活的经历。

所有上海纽约大学的学生在校时的课程都由英语讲授，但外国学生也被要求学习中文。学生们并不会在上海度过四年的大学生活，而是前两年在上海，另外一年在纽约或者阿布扎比校区，或者纽约大学在全球另外 11 个校区中的一个校区。

因此，我们所有的学生，无论是否是中国学生也无论他的专业，都会和来自其他文化的同班同学共同生活相当长的时间。

这样的构成给我们创造了一个机会，让我们在学生刚入学时就传递给他们一个非常明确的信息。我们告诉学生，如果他们希望在上海纽约大学获得最大程度的教育益处，他们就需要让自己坚持沉浸式地联结于另一种语言、文化，联结于那些和他们成长于不同国家的人们的理想与世界观。

我们应当认识到，沉浸式学习第二文化必然对个体而言压力巨大。使用第二语言的难度肯定比使用母语要大很多。起初学生几乎不可能非常完整表达自己，特别在那些细微差别、巧妙性以及幽默性方面。一想到自己可能在别人眼中看起来有点愚蠢，那种感受肯定是不愉快的。

同样，人们也很难与那些文化设定与自己非常不同的人们进行交流。互相误解、无意的冒犯、伤害情感以及冲突的情况到处存在。当人们总是感觉自己是局外人、陌生人的时候，实在让人身心交瘁。

这也是为什么我们不直接对上海纽约大学的学生说，他们只能和来自其

它国家的学生进行交流。我们也不会要求他们必须拒绝和他们有着同样语言和文化的人互动。

沉浸式交流并不是指排他性地和其它文化里的人互动。实际上，它创造了一种日常具有起落和反复的挑战，即在使用第二语言和其它文化人群交谈以及和自己同胞间的娱乐。这种起落需要一天至少两个小时生活在不同于自己最自然的舒适区里，需要活跃地与外国人交流。两个小时是一个门槛，它把沉浸式交流与封闭气泡式的生活加以区分。

好的方面是，如果一个人完全投入这种体验，让自己“筋疲力尽”，那么他会发现第二个月开始压力会小很多，第三个月变得更小。一个人的语言和文化竞争力快速成长起来，超过大部分人的想象。

当我思考上海纽约大学对培养多元文化有效性的举措，我认为我们的努力超越了结构性。它实际上贯穿于我们课程方案的始终。

在选择一个专业之前，每个上海纽约大学的学生在大一第一学期必须修读一门名为“社会全球视野”的课程。参加这门课程的学生需要学习全球知识历史。他们阅读和讨论来自全世界伟大思想家的观点，思考例如人性、善恶、自由与平等、劳动与资本、种族、性别以及国家统治等话题。

在上海纽约大学成立的前三年里，我参与讲授了“社会全球视野”这门课，第一年是和 Paul Romer 教授合教，他是去年诺贝尔经济学奖得主。我们采用了苏格拉底问答法的教学方式，旨在促进细致阅读、提问和尊重性质疑。学生们发现我们所研讨的那些问题的答案并不能从所阅读的伟大思想者那里靠记忆得来，比如，孟子与荀子有分歧，密尔和卢梭有分歧，康德和边沁也有分歧。学生们还发现他们不能简单地从 Romer 教授和我这里得到答案，因为几乎每堂课我两都有不同意见，互相质疑。

在大二第一学期，无论学什么专业，每个学生必须修读一门名为“人文科学视角”的课程。这门课程里，学生学习艺术、文学和音乐。他们阅读并讨论全世界的伟大人文科学，思考相似主题在不同文化传统里的不同探究方式。

这种类型的课程自然而然促进了世界主义的认知。课程开阔了学生知识视角，也开阔了学生跨文化讨论的话题范围。

更普遍来看，我们的课程反映了一种通识教育的理念，要求所有学生在一个学术专业领域有深度，同时又通过学习人文、社会科学和自然科学而具备知识广度。通识教育的理念必然促进多元文化有效性的发展。我必须在这里指出更为重要的一点，它对我前面提到的六种技能之一有极大的重要性：创造力。有关这点的学术研究已经非常明确：相比狭窄的专业教育，通识教育可以培养更多有创造力的数学家、计算机科学加和更多金融专业人士。

我们的教学方法体现了活跃学习的理念，通过所有学生积极参与课堂教学使得他们在小组讨论时提出自己的观点会感到放松自如，哪怕这些观点可能经不起严谨的推敲，他们会心存极为重要的同理心和怀疑精神，也会在表达不同意见时更有心智和礼貌，并且会在多元文化群里中成为活越的成员。

我并不认为其他大学需要和上海纽约大学采取一样举措来提升学生的多元文化有效性。任何一个大学，无论它的组织架构如何，都可以给自己的学生传达一个明确的信号，那就是他们的大学时代是一个转型期。高中教育是教师为中心，学生的任务就是掌握他们从教师那里获取的信息，但他们的大学经历则是学习为中心，是掌握专业知识和接受广泛教育熏陶的结合。

任何一个大学都可以要求它的学生用一年时间在海外学习，或者至少一学期。只要学生们在这期间有沉浸式交流，只要他们不试图只生活在与他们自己同胞组成的圈子里，他们就能有多元文化有效性带来的生活变化体验，40 多年前，当我在法国 Sweet Briar College 度过大三时，我也有过同样的体验。

正如我在开头提到的，我相信大学有道义上的责任为学生毕业后甚至毕业十年后做好准备，不止是仅仅培养学生就业。我们需要让学生为百年生命做好准备，培养他们国际竞争力是为做好这一准备不可或缺的部分。

（译者：李冰）

信息时代的教育

图灵奖得主，中科院外籍院士，康奈尔大学教授 John E. Hopcroft

很高兴今天有这个机会能和大家讨论面向信息时代的教育。我从我们人类进化过程中经历的若干次革命开始。我们现在正在经历的革命，其影响力和农业革命、工业革命一样重大。每次革命都以前一次革命十倍的速度加快发展着。在人类刚开始进化的早期阶段，人类聚集捕猎。随着农业革命的到来，社区得以形成，人口得到增长。今天，我将着重讨论教育。

在工业革命之前，人们并不需要非常正规的教育。如果你在一个农场工作，你只需要从父辈那里习得有关技能。但随着工业革命的到来，高中和大学教育变得非常重要。进入信息革命时代之后，人们需要更加强大的教育。我想提一下发达国家所拥有的资源。工业革命后，材料和能源成为发达国家的制约因素。但进入信息革命后，人才是最关键的因素。中国需要关注的是发展世界级水平的教育，为成为世界强国提供足够的人才储备。

基础人才在世界范围内是平均分布的。据此，中国拥有全世界 20% 的人才，但教育机会却不是这样。中国要成为世界强国，必须为所有的公民创造世界级的教育机遇。我想谈谈哪些因素可以促进教育达到世界水准。我主要围绕本科生教育来展开。首先，管理者并不必须马上提升整个大学的课程。如果你先选择五个重要院系，集中精力提升这五个院系的本科生教育，就可以做出有巨大影响力的事。你也不需要提升整个院系，可以从选择十门重要

的课程入手。

如果一名教师一年讲授两门课，一学期一门课，这意味着你只需要 5 位出色的教师。经济学家告诉我们，你评估什么就会得到什么。因此你必须确保你激励的是那些正确的事情，比如教师的教学质量和职业声誉由国际专家进行评审。你不应当仅仅去计算研究经费和发表的论文数量，因为一旦你这样做了，你所收获的也就仅仅是这些。当下，必须推陈出新。我想建议的是为新的教师创造一个环境。在那里，你给新教师们支付有竞争性的薪资，并且给他们提供博士生名额，这是对他们职业发展而言最为重要的因素。你应当安排这些教师每学期教一门课程，淡化研究经费和论文数量在升职中的作用，让他们专注于提升教学质量和将由国际专家评估的职业声望。

尽管我聚焦在计算机科学这样一个被视为技术性更强的教育领域中，但为学生提供更宽广的教育非常有必要。大部分学生将不会成为研究人员，而去公司工作。他们将从事的工作范围非常宽泛，个体是无法完成的，你必须成为群体中的一份子。因此，教育学生如何在群体中工作也是教育的一个重要方面。

有一些学生最终到政府部门担任领导职位。因此，提供给他们超越技术领域的教育也很重要。学生应当接触到历史、文学、艺术、社会学、哲学、音乐等方面的知识。我想讨论关于提供世界级教育的话题，因为在有关如何成为一个好老师的研究中，可以发现最重要的一点是这个老师是否关心学生未来的成功。

我想讲一个故事，有关孩子灵魂的鸡汤故事。有一个大学社会学教授让他的学生对 200 个居住在巴尔的摩贫民窟男孩进行个案历史研究，让他们写下每个男孩未来的评估。每个案例中，学生都写下这个孩子不会有未来发展。25 年之后，另一个社会学教授参与到这个研究。他让他的学生跟踪这个研究这些男孩现在的情况。他们发现，这些孩子中大部分人取得了卓越的成就，成为了律师、医生和商人等。

这位社会学教授感到非常震惊，决定去查找是什么原因。他问了每一个

之前的男孩是什么引导了他获得成功。他们的答复都是因为一位老师。这位教师还健在，于是这个教授就去拜访了他。教授问道，“你施展了什么魔法让这些男孩从贫民窟脱离出来？”这位教师给出了极为简单的答案，“我爱这些孩子们”。这就解释了对学生成长至关重要的因素是教师应当关注学生的成功。

我想讨论下如何评估教师。在中国，我认为有些事情应当优先考虑。当我在康奈尔大学时，我制定了一套评价教师是否真正关注学生成功的方式。如果你希望培训一个好的教师，你要求他们关注学生，而不是仅仅坐在讲台后，看着幻灯片讲课。你的声调、手势等，其实都可以吸引你的学生关注，你要和学生交谈，观察他们的表情，发现他们是否真正在听你说话。如果他们并没有在听，你要考虑如何吸引你的学生。我们希望教师关注智力概念。在开始课程之前，你应该弄清楚你希望学生从你的课程中记住的最关键的理念是什么。

数学证明应该简单直接的给出公式的含义，而不是一个精确的语言陈述。与其花大量时间去给出复杂的、精准的证明，何不给出有关如何证明公式的启发式讨论？当学生需要证明时，再给出足够的细节，帮助学生得出答案。仔细检查你的讲义，不要每年重复讲解同样的内容。每次我教课时，课程内容都有所不同，因为我尝试记住之前的学生在哪里感到困难，我如何能把讲义准备的更好。

不要跟从别人的课程大纲。哪怕你发现一个微小但有趣的信息，完全可以包含在你的课程大纲里。事实证明，你讲到的课程材料其实没有那么重要。学生学到的东西超过你课堂上提供的。但当你布置作业的时候，你需要确保作业是和课堂上的重要内容密切关联的，这些作业是阐释重要点的好例子。多用一些简单的练习，帮助学生理解这些知识点。还有一个要点是鼓励学生互相帮助。

如果学生无法完成作业练习，鼓励去问其他同学。这点很重要，学生在这个过程中可以学到在课堂上学不到的知识。当我担任康奈尔大学工学院院

长的时候，世界五百强企业的 CEO 中有 10 位毕业于康奈尔大学。我和他们会面时，我问他们从康奈尔学到了什么是后来对他们成功最有帮助的。他们中没有人提到他们在课堂上学到的任何东西，所以教育远大于仅在课堂上教的那些内容。

我还想谈一些有关大学的使命是培养下一代人才。我们为什么强调教师要做研究？部分原因在于一个教师的职业生涯有 40 年，我们不希望教师在 40 年教师生涯后还在教 40 年前的陈旧知识。投入基本的科研可以保持教师的教学跟上时代。它还能帮助教师聚焦智力观念。但我想说的是，研究并不是我们真正的兴趣所在。

我想谈谈应用型研究和基础研究之间的差别。应用型研究之所以开展是因为国家或者公司有这个需求。在美国，应用型研究一般由公司或者国家实验室开展，并且一般都有时代性。但基础研究的开展是由于你真的对它感到好奇。所以应用研究与基础研究的差别是你为什么要做它。

如果我们对某个研究感到好奇，我们会在大学开展工作。我们希望的是教师从事他们自己感兴趣的研究。一些人从事一个方向研究，而另一些人去做别的方向研究。所有人可以从事不同方向的研究。大部分的研究最后可能并没有价值，但碰巧某些偶然的场合，其中的一些方向可能会创造出一个全新的产业，提供上亿人工作机会。所以事实就是，尽管我们从不去看一个研究的成果如何，但这也许是美国做的最好的投资，即在大学里做基础研究。当我第一次从美国自然科学基金会拿到研究经费时，他们没有要求我必须做那个经费范围内的研究，因为那不是他们资助我的原因。他们希望我能培养更好的下一代人才。如果这过程中有一些观点我认为比之前要好，那么没有问题。我不需要请示谁才能修改我的申请书。

美国自然科学基金会甚至不会跟我要一个结题报告。大学只需要我们提交一个财政报告，有关经费的使用，而我却不需要报告我做了什么研究。我想说在中国我们必须有一些不同的政策。教学应该像伦理道德一样，提到非常重要的高度。你和学生在一起的每个情境都应当最好地契合了学生的兴趣。

比如，在康奈尔大学，如果有一个教员刚启动一个新兴公司，学校不会允许他雇佣学生在他的公司工作。原因在于，对学生而言，他可能有 A 和 B 两个选择，A 是这个教师的公司的最好利益所在，而 B 是学生个人的兴趣所在。这个教员有可能建议学生选择 A 而不是 B。这样做是不道德的。

所以我想谈谈如何评估一个教师。你应当注重的是，这个教师是否对他讲授的内容富有激情？他是否关注他的学生？他是否能够清楚地沟通？他是否能回答学生的问题？能否有效使用黑板或者 PPT ？换言之，你应当坐在一个课堂，仔细观察下这个教师到底做的如何。如果你评估教师，记住那个教师的职业生涯会有 40 年。所以不要过度关注你雇佣他们时他们所做的特定的研究。你希望那个教师保持学术活力，而不是 30 年都在教一成不变的讲义。所以，在雇佣教师时，应当关注他们是否对学生感兴趣，是否对引导探索新的方向感兴趣。他们是否在本领域研究之外有着广泛的兴趣。你真正需要关注的是这个教师是否能在他整个职业生涯保持活力。如果你想帮助教师提高教学，有很多事情可以做。你可以提升他们的教学风格，帮助他们改进教学内容，可以坐在课堂看他们如何讲课。当然这真的非常困难，除非你雇佣到那些真正关心学生成功的教师，否则你确实没有太多可做的。但评估教学这一行动传递出的讯号比评估本身更为重要。当大学在评估教学时，它告诉人们教学非常重要。在中国，如果一个大学校长、院长和系主任明白他们的声誉是依靠教学质量的，教学才会变得有价值和出色。

大学校长有 5 年任期，他们也会寻求更好的职位。如果你只衡量研究经费，衡量他们如何提升大学的科研经费，或者衡量他们如何提升论文的发表数量，那么他们就只能收获这些方面。所以需要让大学校长明确认识到他们下一个职位的去向会依据评估他们提升本科教学质量而决定。除非改变环境和教学奖励体系，否则校长们也无法提升。我想提一下的是，中国的大学教育正在改变。事实证明这对于中国稳定非常重要。中国政府总理会见外国专家的时候，跟我们提到，当前政府的一项重要的职责是必须快速提升人民生活水平，从而保持国家稳定。

要做到这一点，中国必须提升国民生产总值。要实现这个目标，国家必须为公司提供公司发展所必须的人才。这意味着必须提升本科教学质量。我想，大学校长们正在得到这样的指示，大众也会很快看到在中国的变化。什么改变是必须的？我想首要的是改变初级教师的生存环境，因为除非环境得到改变，否则教学不会得到提升。你应该希望初级教师们做他们想做的真正感兴趣的研究，把他们的教学工作量降低到每学期一门课，给初级教师们博士生名额。大学是有一定数量的博士研究生名额，但在很多大学，名额却主要是资深教授才能获得。

初级教师想要获得职业发展最为重要的一件事是有高质量的博士研究生。这意味着你必须预留一些博士名额给初级教师们，并且改变他们的晋升方法，依据他们的教学质量和职业声誉。中美的环境存在差异，因此必须发展一种与环境相适宜的战略。或许我们进行这样的实践：短期内给大学设定两个使命，一是产生下一代人才，另一个也许是必须帮助开展应用型研究，因为公司并不能雇佣到足够的有资质的科学家和工程师。

但我希望能确保实践应用型研究的使命不会去破坏教学环境，因为培养下一代人才是更为重要的使命。这样一个国家才有足够的人才在公司和国家实验室从事应用型研究。有了重视教学质量的环境才能形成对高质量教学的奖励体系，因为这个环境去除了研究经费和论文数量的压力。请告诉教师们，大学不看重这些。

我相信，大学的使命是培育下一代人才，开阔他们的人生。世界正在改变，这些主题正在被社会关注。技术型教育很重要，但广阔的技能也被迫切的需要。领导力对于新一代人才来说也非常重要。

（译者：李冰）

从法国人的视角看如何培养学生的国际能力

法国高等教育部国际合作与交流司司长 Joaquim P. Nassar

首先，我想感谢上海交通大学致远学院邀请我做今天的演讲。我演讲的主题是培养国际学生的国际能力。我将从法国人的视角对这个问题做出解答。

请允许我先介绍一下法国的高等教育体系，这对我们来说可能会是一个挑战。格林斯潘曾说过，“如果你能理解别人讲的是什么，就说明他的解释可能不是特别的好。”这句话从侧面反映了法国高等教育可能面临的一个问题。目前法国巴黎政府正在开发培养法国学生的国际化视野，特别是国内外发展的能力。今天，我们致力于将我一半需要在上海交通大学完成的案例分析尝试着应用于在中国高校试运行法国教育系统的举措，并计划发现此试验带来的相关挑战。

大家可以先看一下有关法国高等教育体系的一些数据。法国高等教育的本科生总数约为 260 万，相比之下，中国每年约有 900 万学生参加高考。两国的数量级不同。这一数字的增长是由于人口统计方面的原因，也因为现阶段法国出台了一项政策来促进更高比例的法国学生接受高等教育。我们每年在公共教育的支出是 3030 亿欧元，约为 23000 亿人民币，这大概是 2016 年国民 GDP 的 1.5%，也许还远远不够。如果评价我们的政府在学生身上花了多少钱，尤其是由政府资助的高等教育，这个预算在 11,000 欧元左右，约合 88,000 万元人民币。

本科教育，是我们今天国际论坛的重点，这不单单是一个欧洲概念。在美国和中国，通过四年的学习，你将获得学士学位，这是一个非常重要的里程碑。4 年后，学生可以自行决定要不要继续攻读研究生，或是直接投入到博士的研究中去。这与欧洲是有所不同的。在法国，所谓的学士、硕士和博士学位体系是一种循序渐进的制度，学士学位在欧洲是 3 年，硕士是 5 年，博士是 3-4 年。现阶段，对于欧洲的职业教育，尤其是工程教育，更多的是关于硕士阶段的教育，而不是学士阶段的教育，希望大家对这点区别有一定的了解。

大学是要有教育大众的职能。在法国，大约有 150 万名学生进入大学学习，我们可以看到这个数据很复杂。目前，有 73 所公立大学，遍布全国各地，涵盖所有学科，提供各种层次的学位以及研究活动。在这些大学里，员工总数约为 15 万名。简单地说，在德国的大学里，高等教育是大众化的。所谓的精英高等教育，在法国被称作是”Grandes Ecoles”的现代职责。“Grandes”的意思是大，但实际上这些学校的规模并不是特别大，你可以把它看作是法国悖论，这其实是历史的残留问题。一些从历史上留存下来的教育组织自十八世纪以来与大学系统并行。在高中毕业后，学生在法国完成所谓的“学士学位”后，参加这些课程是正确的选择。根据数据来看，有大约 8 万名学生参加了这些预备课程。这些课程涉及的领域广泛，比如工程学。目前有 200 多所学校开设了相关课程，这些学校大约有 700 名的学生来自小型学术研究机构。此外，管理研究主要是这些”grandes ecoles”的责任，实际上，细节都是一样的，这是一个显式的系统。

今天我们来谈的法国教育必须需要确保我们所在的是统一的教育体系。因为在大多数欧洲西方国家，即使是最发达的国家，精英和大众之间的分离因素是一种威胁。在许多西方国家，民粹主义和民族主义的价值很高，大众认为国际化和特权阶级是威胁，提高整体国民素质是亟待解决的问题。在这种大环境背景下，国际化对于大众教育来说是一种挑战。精英学生是有非常全球化的思维方式，因为他们拥有丰富的国际化资源，他们把国际教育作为

一个跳板，这使他们和普通学生会有一个自然的区分。很明显，这是我们在教育政策中必须考虑的。为了联合不同的系统，历届法国政府都鼓励建立集群，将大学、大众教育、研究中心和公司研究中心聚集在一起，其目标是为了整合高等教育研究进行创新，并在大众教育和精英教育之间架起一座桥梁。这一举措在一定程度上受到了国际商业化的推动。一系列的整合过程相当复杂，在国际大环境中举步维艰，这个举措的核心是减少高等教育研究的集群数量。在国际的关注下，我们可以将它们分为两种类型：一种称之为 IDEX，它是指综合性的大学；而另一种就是一些特定的专科性大学，它只在某些特殊的领域培养人才，我们称之为 I-SITE。所以之前我提到的法国政府的目标是培养国际意识，不仅对于精英，而且包括大众。

我完全同意雷蒙教授的演讲，在学习和工作过程中具有多元化的视角并且时刻进行国际比较是非常重要的，尤其是从经济角度来看。在欧洲地区，如果你想在一体化的欧洲公司里工作，作为一个法国人，你必须足够了解德国人会怎么想，英国人会怎么想，比如当英国人处在一个复杂的过程中时，以英国退出欧盟为例。你还要体验和中国同事、巴西同事等等共事的感觉。你要通过这种市场的机动性来适应这种多元化的磨练。了解资本市场很重要，如果你想了解消费者的口味，如果你想开发出在世界范围内都能成功的产品，你需要知道世界上其他人是怎么想的。

法国是一个流动性比较高的国家，我们大约有 30 万外国留学生在法国学习，这使法国成为第一个非英语国家的全球第四大人口流动国。观察在法学生的流动性问题，中国是世界第二或第三大留学生来源国。今后，我们也将大力鼓励更多的中国留学生赴法深造。我们特别组织了关于赴法学习的学生满意度调查，报告显示绝大多数的外国学生在法国学习的经历都有非常正向的体验。因此，为了在留学生中获得更高的认可度，政府近期推出了一项名为“选择法国”的实用战略，即在 2027 年之前，通过更加多样化的留学政策吸引国际留学生，预计使国际学生人数增加到 50 万名。例如，通过简化签证申请程序，让学生更快、更便捷的获得签证。同时，我们意识到法语

对许多国家的学生来说都是一个挑战，所以我们将提供更多的项目来帮助外国人在日常生活中学习法语。同时，准备更多的英文课程项目，为用英语教学的新项目提供更多的支持。然而在法国，鼓励发展用英语教学的课程是很危险的，因为这不是典型的法国人和德国人的思维方式。由此会产生一个问题，就是法国传统上非常低廉的学费将会被调整以资助这些海外学术项目，此举将会更明显地兼具当代法国教育的特色。

法国是全球第六留学生输出国，中国目前排名第一。如果你观察法国学生去留学的国家，有一个大国不在前 25 名之列，那就是中国。我们希望鼓励更多的法国学生去中国学习，不仅仅只作为六个月的交换学生，而是成功的完成整个大学过程的学习，并获得相应的毕业证书。中国的海外流动主要集中在欧洲，因为著名的 ERASMUS+ 项目，这种情况已经持续了大约十年，在这里，我就不过多赘述了。

接下来要做的是提升法国学生的流动性。很多大学鼓励留学生回国，这是今年推出的一项新举措。在欧洲的大学里，你可以运用 4-6 个机构的网络，互联网的贯通使学生更容易从一所大学的学习进入到另一所大学的学习中。学生们可以在一所大学完成一个学期的学业，并在另一所大学完成另一个学期的学业。通常，这也将提供给来自世界其他地区的访问学生。我刚才提到的法国教育的联合效应也确实应该更加符合广泛的共享策略。事实上在很多地区，正如你在这张地图上看到的一样，法国的海外教育也将是政府战略中更明确的一部分，法国教育在世界许多地区都有体现。中国显然是当前实施法国教育的优先目的地之一。

在接下来的演讲中，我将专注于一个案例研究，它是我在上海做的一个研究项目，即在上海交通大学如何贯彻执行法国的高等教育。先简短的说明一下，在法国，工程师和工程师主管是一个规范的头衔，我们有一个专门的组织 CTI 会对工程师的工程数据进行考察认证。CTI 实际上定义了工程师应该具备的品质，这在他们的网站上用英语写的都很好。我们可以看到工程可以被定义为在创建、设计、生产和实施的各个领域中以一种有效的和创新的

方式来提出和回答复杂问题的方法。在一个竞争激烈的环境中，专注于产品、系统、服务、同时可能还有融资和销售，是一个卓越的工程师所需要具备的能力。因此一个卓越的工程师基于坚实的科学背景，应该对技术、经济、社会和人类的问题有很好的理解。工程师的定义是要比技术工程师宽泛的多。

一个工程师应该具有广泛的技能属性，要为漫长的职业生涯做好准备。与此同时，工程师需要从事不同的研究活动。当在一个分支内开展活动时，研究和创新必须成为工程师意识的一部分。良好的沟通技巧和超前的国际意识被认为是工程师内在技能的一部分，这大概需要花费一生的时间去培养工程师的这些能力。在法国，我们认为基本上可以用 5 年的时间去培养具备这样能力的工程师。一般来说，为了确保长期的适应性和分析能力，你会花很长时间去打造坚实的基础，主要是通过学习巩固数学、物理、计算机科学和化学方面的基础知识。这通常是要通过两到三年的高强度训练和严格的课程准备才能实现的，而且这仅仅只是一个基本阶段。通常，学生会在很晚的时候才能发现自己的专长究竟在哪里。如果你未来想成为一名法国工程师，无论你有什么想法，你都要和那些想成为数学家的人一样接受数学训练，和想成为物理学家的人一样接受物理训练。就像 1997 年诺贝尔物理学奖得主 Cohen-Tonnoudi 说的那样，“我在预科期间所接受的教育在我接下来的科学生涯中发挥了至关重要的作用。如果没有这些由杰出教师传授的数学和物理知识，我不可能达到我所达到的水平。”

在掌握了你需要的实用技能后，你需要尽早开始步入你的职业生涯。职业专门化通常发生在中国大学的后期，与工业企业紧密合作，通过企业专家直接参与教学和学生去企业内实习中获得，有的也直接来自于中国工程教育领域，这同样也视为课程的一部分。中心在中国的贡献来自于在大学阶段实习的学生。因此，中法工程学院在中国开展了法语教育实验基地，这是中国政府对法国高等教育的一个高度认可。中国政府在承认赴法留学生得到良好培训后，鼓励中法院校来华开展工程教育，这些学院是中国政府改革高等教育战略的一部分，目的是在中国的大学里试验成功外国的教学模式。在上海

交大 - 巴黎高科卓越工程师学院成立之前，北京、天津和珠海就已经设立了一些中法研究机构致力于核工程。这些城市之间建立了友好伙伴关系，我所在的学院从 2012 年开始与上海交大 - 巴黎高科卓越工程师学院合作。上海交通大学和四所法国大学合作，这种合作可能是独一无二的。我们的联合项目以培养高素质人才为使命，旨在培养具有广泛科学背景、在多元文化商业环境和一个专业领域中发展能力的国际学生中的行业领袖和创新者。我们有三个专业领域：ICT、机械工程和能源动力工程。发展中法研究、推动创新，是这些机构的明确使命。

我还想谈谈在上海交通大学实施法国式教育时，我们需要面临的一些挑战。与中国模式不同，法国模式在中国很少为人所知。首先，我们需要了解这种模式对中国学生及其他们的家庭是否具有吸引力。中国学生，中国家庭，如果他们了解法国的教育体系，事情就会变得简单，那么就能解释课程的价值，它与主流教育体系有显著的不同，尤其是在加入就业市场的时候。但到目前为止，至少还没有可能。你必须向学生阐述学习的价值，尤其是学习法语的价值。目前他们完全了解学习英语的价值，但就法语的价值而言，你需要做这方面的努力去让他们了解。

我们的课程与大众课程相结合，包括本科阶段和硕士阶段的学习。对于学生们的好消息是，在他们取得学士学位后，他们有很好的机会去法国继续攻读研究生。虽然这对学生来说是个好消息，但这对我们的研究机构来说确实是个挑战。很明显，如果你想在中国的大学体验国外的教育模式，最重要的是人脉和可持续发展力。一般来说，你需要确保外国教授的长期权益和科研的参与度。教授们通常对来上海任教一两次或三次的机会感到很兴奋，但如果是五年、十年呢？这是一个更大的挑战。目前，我们有一部分讲法语的教师，这在中国是一种罕见的资源。我们怎样才能招募到高水平的会说法语的中国教师然后你们如何培养这些人才，这是个严峻的问题。他们中的一些人也提到，中国的教育体系能给那些以教学为主的老师和教授带来好处吗？同样，这在中国是一个非常重要的争论。当你真正致力于教学时，你就没有

那么多的时间用于研究成果和发表论文。在中国有很多的困难需要老师们去克服。我们提供基于 SJTU 硕士学位的法国工程数据。我想大家都知道，这两种制度的目标实际上是不同的。当你即将在上海交大完成硕士学位时，通常你只有很少的课程，因为你的导师希望你在 2-3 年的时间里专注于实验室工作和发表论文。在法国的教育体系中，我们第一年的大部分时间都花在发展基本技能上，而专业化是在后面。所以我们在学习的后期，会特别强调在公司的环境中去实习锻炼，学习管理课程等。我们还会有一个时长 6 个月的赴法学习机会，很显然，他们在实验室的时间会变少，这要和学生的导师去反复沟通，虽然他们投入的越来越少，但却能带来不同的结果，因为他们在课程中学到的东西并不是浪费时间。

所以我也想提一下这点，我们到底要如何实现法国高等教育在中国真正地落地，这看起来是一长串的挑战。就在两个月前，我们很高兴地讨论了我们第一批毕业生在中国就业市场的就业情况。学生通过我们之前进行的一系列的技能教授，表现出了非常令人满意的就业能力，这是给予我们的最好反馈。图示是我们两个月前举行的毕业典礼的照片。谢谢大家。

（译者：赵舜娜吉）

新加坡教育经验分享

新加坡国立大学物理系主任　苏重豪

早上好，感谢章教授邀请我来到上海交通大学跟大家分享一些人才培养的想法和措施！我今天的侧重点不在国家的政策上，而在具体示例上。这些是我们在新加坡实施和尝试的示例，希望能听到大家的反馈，并期待与各位同仁更好的开展合作。此外，我还将跟大家分享我校的顶尖人才的培养计划，如：具体措施、未来规划等。我今天分享的话题，包括我参与的一些高中的科学研究项目、一些 Demo 实验室、年轻教育家的项目、UROPS 项目，及其它项目。同时，我还将为各位介绍一个特殊的项目，然后阐述我们如何更好地通过交换项目实现学生能力的培养。另外，我还将介绍我们如何让学生们参加比赛、交换项目，及不同教学法的尝试，以测试能否用不同教学法更充分地去刺激学生们对知识学习的兴趣和热情。

首先，我先介绍高中学生的科学研究项目，该项目学生数量较少，新加坡教育部投入大量时间给年轻学生提供教育项目，以助他们更好的接触和开展科学研究。每年教育部都会举办遴选考试，去寻找约一百位顶尖高中人才。他们会在高中做有趣的考试和调查，希望能给这些学生提供进入大学开展半年或一年学习的机会。一般来说，学生会用两年时间来完成此项目。参加项目可让他们知道研究者的生活状态和情况，我们希望他们在未来毕业之后，能够从事跟研究相关的职业。概括来讲，一些学生会跟着他们的学长、

学姐，高年级学生们会以研究者的方式去引导下一届的学生。有些学生特别专注，有时他们会得出一些比较有意思的结果，比如我们经常会让博士后学生来担任指导教师，并教授这些高中学生回答复杂问题的方法，同时也希望能帮助他们解决一些问题。这是我们一部分比较有意思的论文结果，也能告诉我们这些学生学到或者发现了什么内容。通过参加项目，很多学生最终进入到了一个更高阶的研究领域，如在一些比较重要的期刊上的发表文章等。

下面，我为大家介绍一个特殊项目，即科学展示试验项目。一些年轻的学者们在 NUS 设立科学 Demo 实验室，希望可以通过对实验室的应用来让学生感兴趣，让他们对整个科学感兴趣；尤其是物理，因为我是来自物理系，当然这些不是特别难的课题研究。我们希望能有这样一个平台，来将科学知识展示给学生们。2002 和 2008 年我们都曾到教职员工体系里开展项目，一些学生发现了科学现象，这对他们来说是非常令人激动的。他们会首先找到教授，然后教授帮他们答疑，即解释为何会出现该现象，这对老师也非常有启发性作用。教育部会邀请相关老师参与，进行资源和经验的分享，看看如何能够做的更好。这些举措对教授们也非常有益，比如 NUS 有一位老师，他授课期间不仅携带笔记本电脑，也会带一些相应教具和玩具进行教学，即“移动实验室”。讨论过程中，如有电磁辐射的问题，他会开展非常有趣的实验。至今我们共有约三万五千名学生参与到了整个实验室活动中。有时实验规模较小，每次我们会选拔 20-30 名学生参与，迄今，总人数已达三万五千多人，大家可以想象我们同样一个笑话讲了多少次。

接下来我来具体介绍科研平台，此平台采取用毕业生指导在校生的模式运营，可让在校生充分参与平台活动。首先，参与活动的学生可以了解科学，之后当他们需要接受高难度挑战，尝试去解释科学。听过解释，听众就会知道学生是否真正理解该科学知识。亚里士多德曾说，“教育是最高形式的理解”，因此，学生们会参与教职员的科学项目。我们会让学生们成为科

学大使，让他们向大众或社会去解释一些科学现象，而这将在科技领域促进更多的互动和了解，加深学生们对科学概念的理解。同时，我们也有项目提供让大学生向大众进行科学教育的机会，他们一般需要有自己的想法，来为公众进行培训。新加坡的教育和科技氛围非常开放，我们希望通过这样一个开放的平台给学生们传授科学知识，学生们既可以到我校进行参观，也可以去实验室，那里会有大学生给他们举办活动。我们的一些研究项目，也有大学生参与；有时我们提供 DIY 的工作坊和工具、玩具，让学生可以发挥创造性去动手实践。他们在课程结束后还可把自己制作的作品带回去，对他们非常有激励作用。部分学生也会参与到公共教育的工作当中，有时我们会开办一些科学展，比如在商场这类公共场所进行，因为商场是一个比较开放的空间，我们可以在这种开放的空间给大众传播教育和科学知识。

下面我要介绍 UROPS 项目，即大学生科研项目，我们标准的大学教育时间是四年，在第四年我们会要求学生们开展为期一年的毕业项目设计，这需涉及到很多实验，而这又可以进一步促进学生在早期培养终身的科研能力。我们也鼓励他们在大学第三或四年级参与一两个研究活动，他们可以有长达一年或一学期的时间参加此类项目，我们会对研究活动提供充分的支持，这是我们的 UROPS，我们学生的一个独特的科研机会。学生可跟教职员工一起进行研究，共同体验研究过程中的挑战，共同发现问题。一些教职员工担任学生们的导师，并为学生提供到实验室去解决具体问题的资源，同时也会让他们积极的参与到研究讨论中。学生们在二或三年级即可做到在小组中进行讨论，并开展更多的练习和实验；他们可以尝试感兴趣的项目，这样也可为他们未来的研究打下基础，并增强他们参与科研的积极性。学生的年终毕业设计都是强制性，他们在实验室开展项目研究来解决实际问题，有些是课程当中的研究，有些则是在实验室的一些应用研究。UROPS 项目进展非常顺利，我们会投放大量时间探究如何进一步优化该项目，并进一步提升学生参加项目的体验。学生们通过 UROPS 项目收获颇丰，给大家举几个例子：我

们的一位中国留学生在二级材料 3D 成像的颜色转换方面做出了许多技术研究成果。另外还有激光束的控制问题，学生可以使用小的镜像小的箍，来控制激光束，比如我们这里有个小的箍，它有一个小的镜面，我们可以通过声音来改变激光的形状，比如你用不同的音阶 DO RE MI FA SO，可以产生不同的形状，我们会有这样的方法让学生更有创造性；我们可以让他们在实验室进行各种探索和提高，并会根据学生的需求开设更多实验。学生非常有创意的采用声波的形式来改变激光柱的形状，所以他选择用电脑科技跟箍状和镜面进行结合来实现这一模板，这是非常有创意的。我们鼓励学生们进行尝试，同时也为他们提供广泛的环境和平台进行尝试。同时，我们会给学生举办一些竞赛，比如开设物理竞赛，另外，我们的一些物理学专业的学生参加了国际竞赛，他们用自己在物理领域学到的知识跟生物科学专业的学生进行合作，来实现跨学科的合作，解决一些难题。另外，我们学院组织了一些团队进行跨学科研究，我们的一些学生非常有创意，并在 ESSCS 挑战赛中荣获奖项。学生们反馈说这些活动充分的为他们的未来职业发展奠定了坚定基础。

接下来我将分享交流项目，每年我们都有英国和德国的交流项目，我们会派学生去德国进行浸入式的体验。比如我们现在与多所大学开展了合作，以支持学生到德国不同学校去了解不同的研究及解决问题的方式。比如去他们的物理中心以及美术馆和博物馆进行考察和参观。另外，我要分享的这名学生叫 Keebo，他曾前往耶鲁大学参加了交换项目，并在交换期间拍摄了很多墓碑的照片。我问他为何去耶鲁要拍这么多墓碑的照片，他说这些墓碑其实是一种礼物，是耶鲁大学对它逝去校友杰出贡献的一种致敬。

下面我要分享课程教育法的设计是如何对学生进行挑战的，我们在学校有组织动手的活动，举例来说，比如我想给学生教授水晶结构的理论，而这有时是非常复杂的，如果你只给他们看照片，无法很好的开展教学。这里我们有个透明的盒子，大家可看到盒子里的所有东西，第二个盒子里面有 100

个网球，我们可以把网球放在盒子里面作为造型的工具，然后我们去看网球的排列和结构，这样就可以来了解水晶的结构。你也可以把网球拿出来，通过不同的角度来观察水晶的结构，这是非常有创意的做法，而有时有些教授在上课中是非常无聊的，但借助网球展示是非常有效且有趣的一种方式。有时我们也会用乒乓球，它们的尺寸更小一些，可能会有更复杂的结构。

现在我们来了解下新的教学方式，我们早上十点会有这样的活动，其实这是一个圆顶，然后你可以进行课程教学，这里我们有一个拉链，我们可以在打开球顶后进行细心的观察，你在上午十点就可以做到，这可以帮助大家对天文学与人类史有进一步的了解，这是我们在物理学习中如何激励学生参与活动和研究的。下面的这些是一些小的容器，然后我们让学生抽签，比如学生抽到 4，我们就会把 4 号盒子给到学生，盒子里有一个小的固体物质，我们把它给学生，并让学生在活动结束后撰写报告。同时，我们也有 E-Learning、EDX、网上公开课，还有一些教学提升项目等来帮助学生。

接下来我想介绍一个特殊的科学项目，它是在我们科学教学的教员中得以实现的。这是一个教学模型，被用来讲授一些科学整合科技课程，向大学生推广综合科学的课程教育，这是一个非常特殊的项目，它已经开展了很长时间，是在 1996 年成立的。本质上它其实是一个人才发展项目，目标是让对科学感兴趣的学生们能够进一步增强对科学的兴趣，同时在未来有所建树，这也是一种 21 世纪的科学技术的教育。它是一个跨学科项目，我们会把电脑技术、计算机技术，与实验室相结合。首先我们派学生参加课程，课程中我们可以观察到一个非常有趣的现象。第一个模块的内容是关于原子和分子的，而第二部分则是关于细胞的学习，然后我们会讲地球和宇宙，这是一个从非常微观到非常宏观的课程，学生可以有机会跟不同的教授们进行讨论。这些教授来自物理学、化学科学、生命科学等各个领域，因此说它是一个跨学科课程，覆盖了非常广泛的知识范围。

另外，我们今后还会有一个研究项目，通过回顾反馈来了解各个学科产生的问题，学生也可开展一些讨论，互相挑战以及辩论。这是一个科学项目，学生们有各种可能性来进一步完成项目，我们希望通过这样的项目和讨论帮助学生找到所有他们感兴趣问题的答案，当然这是一门非常繁重、内容非常丰富的课程。另外，我们还有理论基础课程，比如我们有一些非常微观的，从原子分子到细胞到地球到宇宙等的课程，我们的课程是跨学科的，包括数学、物理、生物科学等。这是我们研究的课程，我们需要有这样一些研究方法的教育，同时我们还有开展科学的传播，这也是我们科学任务中非常重要的一部分，让学生可以不断的来做展示。他们在此课程中持续做各种展示，以此来养成并提升他们良好科学沟通能力。另外，我们也有一些特殊配备电脑的实验室，以供学生不断提升电脑科技水平。此外，我们也为学生们开设数学课程，希望让他们用 PATTERN 这样的编程方法来开展自己的研究，我们也会开设科技、编程等相关教学。另外，我们还创建非常活跃的主动学习教室，让学生可以不断的去进行讨论和分享观点，这是非常常见的。同时，我们也鼓励导师制的同辈学习，我们会选派一些高年级学生对低年级学生进行指导，并进行讲述和解释。这样的项目是非常重要的，我们需要有同辈学生的评价，这样他们可知道如何做才能更好，这些高年级学生也将成为他们的学习榜样。很多学生最后选择了 SPS 的科学特殊专业项目及加入学生委员会，当很多学生有一些特殊的兴趣，而我们不给他们提供一些基础设施让他们能不断地形成一个群体来共同研究，那就不会对他们有很大的帮助。因此，我们决定把半层楼的空间作为一个开放的空间，来给学生作为一个交流学习沟通的场所。我们创建了学习大厅、研讨式会议室、图书馆等，同时配备电脑和工作坊让他们进行讨论、探索和研究。我们还会请一些专业的教职员工来参与项目，比如说 Liu、Chameck、Robert 教授等，他们会为学生们进行课程教育，并对我们的专业模块进行教育。我们开设了不同的课程，比如邀请数学、物理学等各学院的老师来进行此课程的教育。许多大学生也参加了课

程的学习，很多高年级学生都成了低年级学生的导师。比如，博士生 Cabel 也参加了本门课程的学习，他在康奈尔大学的导师是诺贝尔物理学奖的获得者，很多这样的学生们都极具才华，我们通过课程项目进一步帮助他们在未来学习中奠定坚实基础。最后分享的是该项目招生情况，每年都有上百名学生申请此项目，我们会招收 40-80 个学生。我们有专家评审委员会，它包括学生、教职员工等人员，申请者会被问到很多问题，如他们对一些科学问题的理解，还有态度问题等。我们甚至还会把门打开，看学生在走出去的时候是否会关门，这扇门可能有些问题，我们会观察他们能否很好的解决问题，我们会在招生环节中设计诸如此类的各种测试方法；同时，我们也会为新生提供多元化的培训。我希望给大家列举的这些例子可以形象地解释我们的特色项目，也希望对未来的教育及团队产生一定的启发作用，谢谢！

（译者：范文芳）

工程学教学范式从单一的技术到系统性的转变

原瑞典皇家理工学院副校长 Ramon A Wyss

本文讨论的是工程学教学范式的转变，从单一技术转向整个系统的处理，我想分享一个具有深刻改变意义的想法，这个想法反映了社会发展变化。我先简单介绍工程教育的背景，虽然大学已经存在了很长一段时间，但工程师的教育却只有很短的历史，这与工业革命有关。可以说是从法国大革命之后，法国成为了以科学为基础的工程教育的发源地，法国教育体系中有一个理念，叫 Challenge Driven Education（CDE），即以挑战驱动的教育模式。该模式要求至少要有一门课程在本科教学当中运用这一理念。事实上，我们每年选派博士生到上海交通大学参加暑期学校，两校早在多年前就有这方面的合作，我会在第二个部分重点说明。

物理学家 Richard Feynman 是我的偶像，他写的书里有很多名言，有一句话我想跟大家分享，“你没有任何责任按别人想要你完成的目标来生活和研究”。有时候学生们太在意他们的父母想要什么，而不是自己的兴趣，我认为如果你真的想要有所成就，只有你自己的热情才能经受住时间的考验。我还想再分享一句名言“宗教是信念的文化，科学是质疑的文化”，但是教

学上也时有二者颠倒，把科学描述为是以信念为驱使。所以，允许学生怀疑和提问是非常重要的。

如果有人去过斯德哥尔摩，就不会错过瓦萨博物馆里展示的一艘战舰，这艘战舰是 1625 年建造的，它被认为是瑞典海军的领先水平。当时瑞典是欧洲的强国，国王亲自下令打造了这艘战舰，但是当国王看到第一个设计的时候，觉得它不够大，并下令重建，1628 年最终完成建造。然而它的处女航行驶 1000 多米后沉船，大约 60 至 70 年前残骸在斯德哥尔摩附近的泥浆中被发现。当人们看到这么大一艘战舰，可能会好奇当时的技术怎么建造？早期没有工程学，都是父亲把手艺传给儿子。在某一时刻，人们会意识到需要特定的知识来复制一些东西，并了解一些原理，例如一艘战舰如何在海面上平衡，这就是工程学的开端。我们必须把科学引入手艺中，这也是工业化的开始。如前所述，尤其在法国，拿破仑创立了巴黎综合理工大学，那里聚集了那个时代最伟大的数学家和机械师，将科学与工程学结合，为工业发展和建设提供基础科学指导。工程的指导原则是基于科学依据来设计的，根据一定的科学验证规则来复制产品的方法成为了自海军工程诞生之初以来工程教育的基石。

从那之后，人们亲眼目睹了造船业发展之迅速，钢铁、蒸汽机等新材料引入。1921 年，有一个著名的断言 : 人类可以打造不沉的巨轮，可是当涉及到技术及其可提供的解决方案时，人类会反思自己的狂妄自大。快速的技术发展定义了工程专业。人们对现有的技术不断改进，提升了柴油发动机使它更坚固更高效，改进了船的钢材料以扩大船的尺寸，提高航行速度。船体各部件的改进

推动了改革的高度成功，这种将复杂部件简化为单一部件的概念在很长一段时间内也一直被定义为工程教育。这部分，我将会在讨论时候详谈。

造船的目的是将货物从世界的一个地方运送到另一个地方，即一种基于系统的服务，货运轮渡是沟通全球贸易重要的交通工具，集装箱是20世纪最重大的航海发明，它使得贸易发生了革命性的变化，这是造船领域的所有创新都没有实现的。集装箱以一种前所未有的方式简化了船舶的装卸，如果没有集装箱的帮助，是不可能达到今天的贸易量。集装箱是一位叫做Malcom McLean的商人发明的，当时他创立了一家公司并在1956年获得了集装箱概念的专利，为行业带来革命性变化。这也给人才培养工作带来思考：工程师如何跳出思维惯式？工程教育应该取得什么样的结果？作为一名工程师，你不仅要为设计负责，也应该看到你的设计需要嵌入的整个环境和系统。因此，我们如何发展工程教育以支持系统知识，帮助毕业生跳出他们的舒适圈？

未来运输行业面临的最大挑战就是温室气体排放和气候变化，运输行业是气候变化的一大“贡献者”，工程师和科学家通过什么样的技术能够降低排放？两年前在《自然》杂志上有一篇文章，如果遵循巴黎气候协议，那么只有三年时间能够维持气候的稳定。根据《巴黎协定》，大气中的二氧化碳含量不应该超过400亿吨，这意味着排放计量需要保持在这个数字之下，我们需要开发降低排放的技术。这构成了对工程和科学的挑战，整个社会如何在保证经济的基础之上改变排放量。有一篇论文的作者声称或许能够将碳排放预算从400亿吨增加到600亿吨，但也意味着气候变暖的风险。更多论文内容阅读请参见：Three years to safeguard our climate; Christiana Figueres, Hans

Joachim Schellnhuber, Gail Whiteman, Johan Rockström, Anthony Hobley and Stefan Rahmstorf; Nature Vol 546, issue 7660

基于气候变化背景下的航海工程的挑战很不一样，它是工程师必须面对的系统挑战。教育不能局限于仅仅改善单独的部分，工程师需要将自己的专业置于一个系统的环境中，例如如何能实现“碳中和”运输，能否完成太阳能驱动来和零摩擦运动的挑战，能否开发不再使用化石燃料的运输业，这是一个系统的挑战，也意味着需要更多跨学科的研究。我们的目标是开发一个可持续的运输服务系统，一个系统内的系统，这对于工程师是一个巨大的挑战也是机会，同时可以预设自己在这项工作中与他人合作的角色。当然，所有系统中最美丽的系统如左图所示，大家都需要好好保护它。

联合国制定了2030年可持续发展目标，请参见：https://www.un.org/sustainabledevelopment/student-resources/ 它们构成了这个时代的全球性挑战，那么应该如何解决这些问题呢？其实，科学、工程和商业都可以为其中的许多方面做出贡献。我们应该将可持续发展目标纳入课程中，以便能够更好地制定解决方法。我认为工程科学的教育、研究和创新对于实现可持续发展目标和缓解气候变化非常重要。作为一个领导者，作为创新的推动者，大学必须承担起这个角色。因此，挑战驱动的工程教育是将系统挑战和国际合作结合起来的工具，就像前文已经提到的瑞典皇家理工学院和上海交通大学之间的合作。

挑战驱动教育的定义是多样的，当我们说它是一个解决现实世界挑战的

学习框架时，是要求学生学会面对并解决现实世界的挑战，这些挑战不是教授给予的，而是由外部利益相关者定义的。它具有合作性和实践性，要求参与者（学生和利益相关者）发现和解决真实世界的挑战，深入了解挑战，以此鼓励他们发展技能，获得深入的学科领域知识，并与世界分享他们的想法。挑战驱动的教育的出发点是，与比如上海这座城市，闵行区，非政府组织，或者提出挑战并拥有挑战的商业伙伴等外部利益相关者，彼此互动鼓励学生不断开发解决方案。因此，挑战是在与社会 (私营部门、公共当局、民间社会) 的合作下定义的，然后进一步细化并转化为可操作的问题陈述，根据问题陈述，开发、测试和实现一个或多个解决方案。设计思维方法的步骤使用，对于与挑战驱动教育和利益相关者交流的合作是一个很好的方法。更多参考请见：https://openlabsthlm.se/professional-courses; https://hpi.de/en/school-of-design-thinking/design-thinking.html

为什么我们需要这样的教学模式？大学教育往往把重点放在给出问题，训练学生解决问题，但很少关注问题的相关性。我们怎么知道这个方案是解决正确的问题呢？我们如何知道这个方案是可行的和理想的，而不仅仅是对所述问题的正确解决？如果这是一个错误的问题，那么解决方案就无关紧要了！对于一个既定的问题，可能有许多正确的解决方案——并非所有这些方案都是可行的和理想的。如果解决方案不可行，也谈不上影响力。人才培养的时候我们要考虑以上这个问题。学生们一定是想未来能够有所作为，我们要在教育中牢记这一点，挑战驱动的教育模式就是希望能实现社会影响力，能让教育直接影响社会。外部利益相关者定义的挑战最终的结果是造福社会。与社会和利益相关者的关系，构成了与传统问题为导向学习的差别。社会开放的回应，外部利益相关者与学生和整个学术界的互动，才能实现对教育的直接影响。

有一些关于社会挑战的理论背景，比如设计理论家 Horst Rittel 和 Melvyn Webber 于 1973 年发表的一篇论文，他们引入了“邪恶问题”一词来描述社会问题，科学家总是习惯于定义明确的有解决方案的问题，这通常是

一个一维过程。很多时候社会问题没有一个既定的解决方案，而是很多解，这意味着学生们必须打开思维。在一般的教育框架中所讨论的问题，通常教授都知道答案，但是面对社会问题，作为教授根本不知道答案是什么。作为一名教师，不知道社会问题的解决方案，因为解决方案的空间概念是如此之大。理解了这一点，教育会随着时间的推移变得越来越重要。之前的一次演讲讨论了延长寿命，我们中的许多人会活到 100 岁甚至更久，这样看来还有 60 年甚至更久的时间，这意味着我们需要学习处理开放性问题。

挑战的特点在于问题本身，从寻找解决方案的角度来讨论，可能有很多解决方案，或者根本就没有显而易见的寻找解决方案的过程。因此在这个过程当中，挑战和解决方案同时存在于这个社会、技术和环境体系当中，它为工程师、科学家、社会学家、律师、商务人士等打开了空间。

为了找到解决挑战的办法，我们需要了解挑战，与利益相关者合作，也需要了解制度和受益人，以便能够定义问题，最终处理问题，开发多种解决方案，这是一个互动的过程，我们必须面向利益相关方并理解他们的观点。

回到这个时代的挑战，即联合国可持续发展目标。如果毕业生没有能力应对这些挑战，还有谁能呢？一名教师的任务是为毕业生提供将那些全球性挑战转化为社会机遇的技能培养。

举两个例子，整合产品设计的项目课程要求从团队协作开始，这是挑战驱动的教育的一部分，需要团队的参与来解决挑战，更好的情况是可以有多学科参与，因为我们需要各种各样团队的合作。就好像有一个团建项目是需要整个团队成员翻过一面强，最后一个翻过去的最难，需要全队齐心协力的帮助才能通过。

另一个例子，一家公司需要建造一个可移动的泵来解决排水的问题，要求泵的抽水速度达到 100 升 / 秒，并且重量小于 50 公斤，易于拆卸和组装。就是这样一个现实世界的、有许多解决方案的挑战，学生在半年内利用课余时间帮助公司研发，最终泵的重量是 36 公斤，抽水速度达到 120 升 / 秒，完全满足了该公司的要求。该设计被公司采纳并进一步开发，学生通过此次机

会获得了信心和经验。

去年，我们把挑战驱动的教育理念引入撒哈拉以南的非洲国家的高校中，我们把来自瑞典的学生以及其他一些合作高校的学生聚集在一起。我们面临的许多可持续发展方面的挑战需要利益相关方、非政府组织、城市、公司等共同承担。我们与利益相关方召开名为“挑战定义日”的研讨会，之后，教师和利益相关者制定挑战声明，学生和利益相关者重新规划挑战，共同学习、共同创造。所有的出发点都是现实生活中的挑战，外部利益相关者和学生作为主体，教师只进行辅助，最终来自瑞典和坦桑尼亚的混合小组提供的解决方案将可能有助于可持续发展目标的解决。通过这种的方式，社会与高校和学生的互动能够得到提升。更多信息参见 [1,2]。

大学课程如何促进可持续发展？从教学角度来说，教师应立足于教师培训计划，理解可持续发展概念，思考如何整合该理念，同时也思考什么是工程师的可持续发展和可持续发展学习，从而制定课程目标、活动和考试。

回到挑战驱动的教育下的人才培养，其目的是解决现存的社会政策问题，即“邪恶问题”。通过让老师和学生打开思维，与利益相关方合作，例如瑞典皇家理工学院多年来一直致力于应对斯德哥尔摩市的挑战，该市从与学生和教师的合作中带来了全新的体验，进一步培养了学生解决问题的信心，让他们相信自己可以真正做到一些事情，这种自信是创新人才培养的另一个重要基石，即对自己和自身能力的信任。它还有一个优势就是帮助学生跳出思维的“盒子”，提升创造力，打破思维局限，形成自己的解决方案，而不是老师直接告知解决方案是什么。特别是对开放的空间问题，有很多潜在的解决方案，它能帮助我们在社会背景下建立对制度的理解，我们可以称之为社会公益，并在学术界和社会之间创造这种互动，这对知识社会是如此重要。

最后，让我引用两句话。一句来自爱因斯坦，他说想象力比知识更重要，知识是有限的，是关于我们现在所知道所理解的东西，想象力让我们拥抱整个世界以及所有的一切将如何理解。这对我们学生的了解和认知是一个重要的信息。

我从我女儿那里得到了斯蒂芬·霍金的最后一本书《重大问题的简短回答》，当我读到斯蒂芬的介绍时我被迷住了，他说在前进的路上，即使他已经不在了，有能力的人可以展现出创造力、勇气和领导力，让他们在面对可持续发展目标的挑战时，摒弃利益，采取行动。时间宝贵，抓住时机，马上行动。

KTH 挑战驱动的教育指南免费下载地址：https://www.kth.se/social/files/56e2b5f1f276541778ae27f5/Guide%20to%20challenge%20driven%20education.pdf

[1] Mutual innovation capacity building through challenge driven education for sustainable development in an international setting; R. Wyss, M. Kissaka, E. Shayo, C. Mwase, A.K. Högfeldt, F. Ishengoma, H. Tenhunen; published at ICERI2019;

https://iated.org/iceri/publications;

[2] Connecting North to South throught Challenge driven education; Rosén, A., Högfeldt, A. K., Lantz, A., Gumaelius, L., Wyss, R., Bergendahl,& Lujara, S. K. (2018). Proceedings of the 14th International CDIO Conference, Kanazawa Institute of Technology.

（译者：林依洁）

人才培养：选才和识才

密西根大学化学系教学副系主任 Brian P. Coppola

有关智力和人才认识的演化

很多年来，教育家们一直在考虑拔尖学生的培养，也是今天论坛的主题。有关这个主题的思考历史，以及它为何发生改变，对于理解中国和美国在设计教育项目方面的不同措施尤为重要。

在美国，有关拔尖人才的培养文章可以追溯到 19 世纪 60 年代，主要集中于学校儿童。1868 年，William Torrey Harris 在圣路易斯开展了一个天才儿童的项目，宣扬了教育和心理学之间的联系[1]。培养拔尖人才与理解智力的模式被紧密而直接地联系起来。

一直以来，人们相信智力是先天性的。在 19 世纪 60 年代，Francis Galton 使用统计相关性得出了结论，智力具有遗传性[2]。如果智力是先天性的，甚至是基因性、特征性的，那么结论无非就是“我是聪明的”或者“我不聪明”这两种。在这个模式中，如果我们能够发现如何根据人们的智力划分人群，那么我们就可以根据他们的天资和技能分配工作和资源。

大约有 100 年的时间，人们相信有关智力的三件重要事情，实际上都是不正确的。首先，如前所述，我们认为智力有先天性、遗传的特性。如果你是聪明的，那是你天生如此。其次，我们认为智力是稳定的。如果你从前是

聪明的，那你未来也是聪明的。第三，我们认为智力是可转换的。如果你能解决化学问题，你也能解决历史问题。

这种智力模式其实是有些幼稚的。确实有些时间里智力是呈现可遗传、稳定和可转换的特点，但这些更多是偶然性的，而非常规性的。家庭、文化环境和经历比基因和先天能力更具有影响性。

很自然的是，当人们相信智力是先天性的，人们立刻开始寻找一个测量智力的系统。如果你能够定义一个定量的测量智力的尺度，并且你相信智力先天说，你应该测量儿童。随之，你再使用智力稳定说来预言，从而给有天资的孩子更多机会发展自身。然后，依据可转换智力一说，你就应当把他们置于有影响力和领导力的位置。

20 世纪早期，在法国，Alfred Binet 和他的学生 Theodore Simon 提出了“大脑年龄”的概念。顾名思义，是回答你的智力是超前还是滞后于你的实际年龄。他们创造了一种可用于儿童的测试，他们认为心智内向的孩子可以放在特殊班级（3）。在 20 世纪 10 年代中期，Lewis Terman 教授，斯坦福大学知名的教育心理学家，在此前工作基础上构建了 Stanford-Binet 测试。此前宣称被测试过的心智的维度简化成单一的数值，即你的“心智年龄”和你“身体年龄”的比率（心智年龄 / 身体年龄 x100），被称为“智商”，即 IQ。

用智商或者用一个标准化测试进行排名，总体来看就像进行一场赛跑。你定义了成功的条件，然后开始赛跑，然后你根据结果选出第一名、第二名等。你不去考虑个体差异和个体经历的影响，而仅仅看赛跑的结果。

你使用的智力模型非常重要，因为这决定了你对人才的培养模式。如果你认为智力可以用一个排序的测试来测量，你就会花很多时间准备测试，过分关注排名。作为一个教育设计者，你会设计出一个程序，把成功定义为比赛表现以及做哪些能获得高分。一旦你把成功定义为一场需要胜利的比赛，你就会知道如何让他人做好准备，你就只需要在重点线等待谁会第一个到达终点。

尽管有关智力的赛跑和测试模型被大范围质疑，多年来依然有很多人相信它。很多社会行为依然反映出这一幼稚的智力模型：很多人倾向于相信某一领域成功的人在其他领域也有指导性意见。然而，某人得了诺贝尔物理学奖并不意味着我们在任何方面都应该听取他的意见，比如文学、政治学，或者买什么汽车和早饭吃哪种麦片。尽管如此，大部分时候人们还是会这样做。实际上，在获得有关智力的推荐和观点方面，人们并不是非常挑剔。这方面我们听诺贝尔奖得主的意见就像我们在购物时听名人、体育明星、演员或者其他大咖们的意见。

从比赛挑选向特质识别的转变

在 20 世纪 70 年代，有关如何培养人才的研究有了显著的转变，因为我们对智力的理解也有转变。在过去的 40 年里，有关智力的模型快速演化。我们创造了诸如“认知”的概念，将智力视为一个发展过程。我们现在关注如何把外部和内部经验转变为理解能力，我们的文化和环境（情境）决定了我们如何确立价值以及解释我们所见和所做。我们应该认识到，同一个人如果有非常不同的生活经历会发展出完全不同的特性和技能。当人们遇到新的情形和挑战时，人们只能依据自己以往的经验和他们对这些经验的认知。

智力和天赋并不是稳定的，它们根据情境来响应。如果我把具备某种潜能的人放在一个环境里，他们的表现会与在其它环境里有所不同。因为他们可以自由决定如何应对自己的环境，他们不仅可以定义自己的天赋，也可以调整他们的环境以达到不同的目标。智力是易变和有适应能力的。

有意思的是，过去十年有关人才培养的论文最多数量的集中在体育竞技领域[4-7]。和智力一样，人们认为体育技能是天生并且稳定的，所以完全可以举行比赛分出胜利者。这一过程可能在明天举行的完全同样的比赛中会有可预言性的价值，但对于 20 年后不同的比赛中，则没有那么多价值。

另一个有趣的现象，现代美国有关学术人才的培养文献仍然主要集中于

针对儿童的研究。你几乎找不到有关大学生培养的资料。人们总是认为真正培养人才的关键时期是儿时，特别是他们养成学习习惯的时候。作为教育者，我们的工作已经从组织赛跑转变为创造环境，为那些年轻人提供成长经验。

近年来，美国大学出现一个令人困惑并且自相矛盾的现象，大学（学院系统、学院）持续根据标准测试定义大学的成功[8]，然而，与之相反，录取过程（大学、研究生院）却几乎彻底摒弃了测试作为一个关键标准。

测试可以告诉你一个人是否掌握了应该知道的知识。但如果智力并非先天的或稳定的，那么你无从得知你感兴趣的这些事情的价值：一个人如何处理不知道或者模糊的事情？如何面对不确定性？如何面对失败？想象力如何？如何培养他们想象力？当这些人一起时，他们会成为哪一类智力或者组织领袖？

通过测试选拔人才的做法一直尝试要成为一门科学。当你假定测试是有意义的，那么你会认为结果也是准确和可信的。测试的确可以预测被狭义定义的“成功”，但它能被用来预测“成功”的唯一场合是你的智力模型假定了你能够测试它，以及一旦被测量，智力是稳定和可转换的。通过测试选拔人才并不是完全没有意义，但它的价值极度并且严格地被限定在测试的主题之中。

识别人才更像一门艺术，因为它是有关个体特征的鉴别。你希望知道，今天一个个体的哪些经历会引向他们明天的成功，甚至在一个目前他们看起来并不具备能力的领域。我认为个体过去如何应对情境的表现会预测他们未来应对情境的能力，我们可以预见他们如何应对指导，可以看到他们如何根据自己以往应对新事情的经验来应对眼下新的和不熟悉的事情。

与选定人才不同，识别人才并不容易。你无法仅仅通过一个测试实现，它需要花费大量财力，对资源有极大的需求。你需要有关学生经历的描述性资料并进行面试。作为一个面试者，你得掌握一种特殊技能来识别哪些特质是一个未来成功个体所具有的。这在一开始几乎是做不到的。如果你是做这些高度主观决定的面试者，你可以具备个人偏好。你会倾向于识别那些和你

自己最有可比性的人们。

从 20 世纪 70 年代开始，有关具有天赋的学生的文献已经和标准化测试分离。以下是 1975（9）年发表的关于建议教师识别有天赋学生的标准：

(1) 学生作为学习者的行为是什么？需要观察的特质：学生是否使用了高水准的语言表达？他们是否乐于接受新挑战，他们是否是有洞察力的观察者？学生是否广泛使用类比法，帮助他人理解自己的观点？

(2) 学生作为个体人的行为是什么？需要观察的特质：面对复杂任务或者失败时，他们是否有毅力和灵活性？他们是否有计划性并且能够预见可能的挑战？他们是否观点鲜明并且能够用有说服性的辩论维护自己的立场？

(3) 学生作为创造者的行为是什么？需要观察的特质：面对不确定性时他们是否敢于冒险？他们能否不武断地思考，质疑那些别人不敢质疑的假设，他们是否习惯于不随大流？他们能否根据变化的假设分析，找出多个解决办法？他们是否具备其他人不具备的幽默感，因为有幽默感的人们通常能很灵活地同时识别出一个场景的多种因素，并且使得这些场景有极其有趣的结局。

(4) 学生作为领袖的行为是什么？需要观察的特质：处在一个需要时常被人攻击位置的他们是否自信？他们能否说服他人并让他人接受自己的见解？他能否做一个好的计划并执行到底，包括必要时候承担责任去实现目标、分享功劳并理性地去冒险？

以上这四点！在 SAT 测试中并不会考到，也不会在 GRE、A-Level 考试以及中国的高考中出现。在智力不是天生的世界里，这些就是我们相信可以用来识别天赋的类别。这些类别不会在任何考试中出现，它们实际上根本无法用任何考试测试出来。它需要一个人运用有价值的判断来做鉴别，需要具备经验去明白学生的语言表达，以及用一种有意义的方式读懂和评估这些信息。

使用测试是最简单的，但如果这个信息实际是无用的，它再简单也没有意义。找一个借口来使用测试，这个做法是错误的，比如“总之，聊胜于无”。如果你使用一个测试无法达到鉴别天资的目的，那么你就会错过一些

真正有天资的人，因为他们在那些测试中排名很低，而那些高分者仅仅具有考高分的天资。

按标准化考试结果来排序的唯一途径是，你是否相信智力是天生的、稳定的、可以转换的。因此，在美国高等教育中，已经开始有很明显的 SAT 和 GRE 分数转移倾向，转向对学生复杂成绩的“全面评估”，包括描述性经验和他们如何评价自己，以及他人如何评价他们。

中国和美国

当 1977 年中国从头开始构建高等教育体系时，智力天生的历史模型也存在过。实际上，中国古代的皇室教育体制不仅是建立在以考试为基础的成功之上，还依存于一种惯例的假设，即基因（皇室家族部分）才是最至关重要的。智力领导者严格意义上是“生出来”的。

40 年后的今天，处在领袖位置的第一代大学生（1977 届）重构着高等教育体系。教育改变的速度巨大又让人印象深刻，激情澎湃。

中国教育体系目前有一个显著的缺陷，即大学之前的教育呈现出与当下有关智力的观点完全孤立的现象。今天，中国的智力模型依然是基于一种认识，即举办一个比赛，选出获胜者，这样就能鉴别出下一代精英。

往好处想，这个观点是幼稚和过时的。往坏处看，它会阻碍中国智力能力和贡献的实质性增长和发展。

中国大部分大学目前正在尝试的变化恰恰是正确的事情，尤其是各种荣誉项目给学生提供选择和机遇。但仍然有一些主要的障碍：（1）选拔和排名体系依然体现了智力绝对论的观念；（2）大学前的教育甚至更糟了，教师培训以及教学体系依然建立在之前陈旧的信仰之上；（3）几乎高等教育中的教授和管理者是以往系统培养出来的，因此他们会抗拒选拔体系的变化。

很幸运的是在过去 20 年里，笔者在中美之间参与高等教育，特别是在北京大学、南京大学和上海交通大学。毋庸置疑，中国的本科生比美国本科

生更加做好了上大学的准备。尤其是在学科内容的更好准备，和适用于一种特定学习方式的极为优秀的技能。

在美国，高等教育体系整体来看非常糟糕，教师培训质量不高，教师的职业生涯也明显要短。这些情况正在变得更糟，并无好转。

相比中国学生，美国学生进入大学的方式非常不同。总的来说，中国学生进入大学时就选择了一个专业，并且通常通过考试实现。虽然有时他们可以改变主意，但这并不常见。在美国，学生在头两年并不确定专业，我们也不关注这点。我们鼓励学生在各个领域开放而自由的探索。美国学生可以周一决定学化学，周二就改变主意去学历史，这都没问题。在周三，他们可能又会改变主意，又会想学化学，也可能会想设计一个他们自己的环境化学专业。没问题！我们关注的唯一事情是最后毕业时是什么专业：不是你想成为什么，而是你最终成为什么。专业实际上在毕业时才确定。

美国学生的公共课程非常多（10）。学生注重组织和领袖角色，不仅在俱乐部，更多在大学社区和本地社区大量活动里，很多时候甚至是面向全球的活动。笔者所在的大学提倡并且讲授这样的学分课程，在教师的指导下完成（并不一定限定方向）。学术成功仍然很重要，但几乎所有学生都关注他们作为学习者在 GPA 之外的经历，他们在一个集体文化中的体验，他们创造新事物的体验，以及他们在发展和领导某种独特活动中的体验。

此前，笔者公开指出过针对中国大学教育系统的三点批评意见[11]，似乎得到了很多人赞同：（1）中国大学没有发挥学生在学科知识储备方面的优势。中国学生有很好的先修知识准备，而大学里很多的导论课只是在重复他们以前学过的知识，不是在教授新知识。（2）中国大学学生应该被更高的要求，他们能够承受更多，特别是 2019 年的今天，科学领域应当在实验课程中加入更多实际的科研活动。（3）中国大学生的课程太多了。学生几乎没有时间思考。他们需要时间思考，需要思考自己感兴趣的东西。

请记住一个事实：美国学生在申请美国研究生项目时和中国学生竞争激烈，但美国学生可能只有上了中国学生三分之一的课程，课堂时间远远少于

中国学生。你不得不回答的问题是：美国学生上了这么少的课程是如何具备竞争力的呢？有一点可以确定，上这么多的课其实并不是非常必要，学生不需要每周这么多时间坐在教室里。

在美国，我们强烈鼓励本科生从一入学就开始接触科研。在密西根大学，25% 的新生分布各个学科领域，他们都受到支持参与教师的科研——从化学到历史。学生还将获得酬劳。教务长每年拨款 500 万美元用以支持至少 25% 的新生进入科研，所以学生不用去麦当劳打零工挣钱。

对学生而言，美国的荣誉教育也是一个相对自由的选择。荣誉教育的主要目的是通过提供学习者、个体、创造者以及领导者的经历，让学生发展那些至关重要的行为能力。新生们并不是完全根据他们高中的成绩被挑选进荣誉项目，因为高分并不被认为会在大学环境里必然创造出成功。

荣誉项目的选择有所不同。在密西根大学，化学系设立于文理学院之下，只是文理学院 75 个组成单位之一。我们的文理学院每年录取 4500 个学生，排名前 15% 的学生会被邀请参加学院的荣誉项目。作为学生，你可以决定你是否要参与这个项目，要求是修一些特别的课程，并保持你的 GPA 在 3.4 以上。系里也有自己的荣誉项目。我们提供荣誉课程，或者同样课程的荣誉标准。我们还会提供荣誉学位。我想强调的是，我们认为至关重要的是学生获得了什么成就，而且由他们自己做决定。他们之所以展示出他们的天赋，是因为我们提供了一个环境让他们得以选择和获得灵活性[12, 13]。

文化和经历的影响使得改变不会快速发生

在中国，有五个变化应当同时发生。当然，相比单纯学习美国的教育系统，这要困难很多很多：（1）课程体系的设计应当少一些严格的规定，进行内容更新，赋予灵活性。（2）学生的期望文化应当被改变，毕竟进入大学前他们已经经历了 12 年的考试和排名。（3）教师按照他们自己经历的教育而

形成的教师期望文化应该被改变，否则系统只是在不断自我复制。（4）大学前的教育计划以及教师培训应当改变，要体现智力的不同模式。（5）发展耐心！这个变化不可能像立刻进行革命一般翻天覆地，但它必须从目前的现状开始演化。

我想转到我自身的经历来支持我的观点。作为一个学生，在上大学前我处在一个非常灵活的系统里，我可以有很多选择。在大学时，我必须自己做所有决定，选什么课、什么时候上课、选修课是什么。在我的班级里，我有科研项目并且被提供了多种选择。从很早开始，我就可以探索如何做研究，即便只是一个小规模的项目，但它仍然是一个实际未知的、可以设计新的实验。

自始自终，我的教授们都很关注我。我现在明白他们在观察我的行为和我做的独立决定，不仅仅是我取得高分。我证实的潜力得到了认可，随之我被放到新的环境里，继续被观察我如何行动，而我被选中并不是因为我的GPA 很好。

作为教授，我现在就在复制这个行动。我的一部分工作是创造我可以观察学生学习者 - 个体 - 创造者 - 领袖特质的情境。这些情境没有一样会在测试中发生！

中国文化里有一个有关如何识别隐藏的才能以及这个才能如何特别的成语：伯乐相马。

伯乐并没有选择一个千里马。如果只为这个目的，伯乐只需要举办一个千里比赛，设一个起点，看谁跑第一。任何人都可以办到，因为这样的操作如此容易。伯乐真正的技巧在于洞察一匹马，并且判断谁会成为千里马。

这就需要伯乐来识别。正如我说，作为教授，我们的工作也是伯乐的工作。

如果你认为才能是先天的，那么你只要举办一场比赛（给出一个测试）来看看谁会赢（给出排名）。如果你想找一个人来做这些已知的事并且未来也还是这么做的话，那来场测试就是你想要做的。这是挑选，但不是伯乐的

工作。

识才是创造机会让他人成长并证明一个才能。我们正在判断的是一种可能 20 年以后才能显现的潜力（对于马儿则是一千里以后才会显现）。

挑选和识别这两个词被用在有天赋和才能的学生的研究里，但我想说的是天性和培育之间的对战。才能是先天性的（天性）吗？或者说它是可以被发展的（培育）吗？当然，它是这二者的平衡！你不能忽略任何一个。如果你遇到一个有很棒潜力（天性）的人，你却提供了很糟糕的环境，那你无法培育他。如果我们用了错误的标准去识别人才，比如考试，那么他们对环境的需求就非常多。我们也许不可能让一个学习考试技巧 12 年的好的考试者忽然变得有创造性。他们没有经验，并且由于智力不是天生的、稳定的和可转换的，完全没有任何理由去期待一个会考试的人去做除了考试之外的事情。

我成长于一个识才的文化中。我很幸运被鉴别为有天赋和才能的学生。我乐于成为伯乐。我愿我有“高伯乐”的眼光。这是有经验的眼光，是我自己学生时代的经历造就的。

根据我的经验，我可以设计课程体系，让千里马们展现自己的才能。我也有偏见。如果某人告诉我必须使用考试和排名，我毫不犹豫的说不，因为我认为它们毫无用处。

美国博士项目里的中国学生和美国学生

在准备这个报告时，我让我的同事们比较他们新录取的中国博士研究生和美国博士研究生。他们说“第一年的时候，我喜欢中国学生。他们对学科知识掌握、专业才能和实验室技巧方面掌握的非常强。我只需要说一次，他们就可以在实验室开始实践。”

当发展一个新观点和新技能的时候，后续会发生什么？

美国学生并不比中国学生更好，但他们会更敢于尝试一些听起来疯狂的想法。中国学生也可以在新的情境里做的很好。在我的同事看来，学生个体

的特质的影响最大。我一个同事用了一个我非常赞同的表达，他说我们的学生需要的“天真的勇气”。天真的勇气意味着他们不需要知道每件事，但他们认为自己可以做任何事。他们只需要去尝试。如果他们在这样一种支持开放思考的文化里生活和工作，他们就能实现。

这就是环境文化具有影响力的地方。如果你在挑选的文化中，你的学生带着一个看似疯狂的想法来找你，你可能会说“这太不切实际了，肯定不会成功，按照我的方法去做，那是正确的方法”，因为你受限于自己的知识水平。在识才的文化中，学生来找你，也许你脑海中会闪现“这太疯狂了”，但你却会说“试试看，看看它进展如何，会发生什么”。很快的，你会认为它们是学生产生的想法，而不再认为是疯狂的。

在博士生项目中，有一种语言上的变化我强烈反对。这就是研究生用来形容他们与导师关系的词。几乎所有人谈论到导师时会这样问：“谁是你老板？”我很憎恶这个词。当我读研究生的时候，我“和我的导师一起工作”。我从来不会说“我为我的老板工作”，我从来也没有这样的想法。如果我说“我为老板工作”，我的导师可能会揍我一顿。

在学术圈，我们关心博士生是因为每个新的教师都来自于这群学生。我们对下一代教师负责，我们创造的环境，以及选拔和识别人才之争是非常关键的。我想，我们完全可以这样说，没有一个人会关心一个新的教师是否曾是一个好的考试者。尽管科研成果非常重要，但也不是博士项目最重要的输出成果，而是因为博士项目是未来教师成长的地方[14]。

我的导师 Barry Trost 是一位世界著名的教授。他总是说研究不是他工作的最根本输出，新的科学家才是。“如果研究结果是我的根本目的”他会问，“我为什么要和没有经验的科学家一起工作？如果研究输出是我的根本目标，我只需要雇佣博士后来完成实验。我的工作是尽我所能教育好下一代科学家。”[15]

做些什么？

作为教育者在每个层次，我们的目标是培养下一代人才。在学术界，这是我们独一无二的责任。社会上没有其他任何人承担这个工作。

所以我们要做些什么？我想中国需要一个伯乐方案——改变有关人才培养的课程体系、学生、教师和学校体系的固有观念。

这必须是一个几代人的项目，因为需要改变的是文化环境。中国比其他任何国家更能理解，通过快速变革文化环境并不奏效。你必须有耐心，你必须思考长远。这是一个 30-40 年的计划，而非 5 年计划。

第一个目标是使用你已有的、改变你能改变的。

中国拥有那些在进入大学时已经有非常出色学科知识和技能的人才。所以，在这些强项上来做文章。

第一：停止测试和排名。坦率的说，我完全不在乎这些。你是在为谁做测试和排名呢？如果没有人使用这些信息来做决定，它就是不必要的。

第二：减少学术要求，给学生实践思考，让他们思考有趣的事。

第三：改变科学最佳的地点是实验课。如今，在一个实验课上你可以利用现代装备的优势。现代装备可以让你完成实验课上真正的研究。在美国，有很多地方正在把研究与实验导论课相结合。研究不一定是要马上找到治疗癌症的方法。研究可以是小而未知的，学生可以不昂贵的现代装备收集到个体数据。

我发现中国有些实验室还在使用我读书时使用的过时装备来做实验，而现代装备实现了只需要少量的材料就能完成真实数据快速收集。这意味着学生在大一阶段就可以提出问题，设计研究，而且是在一个较大范围意义上进行。这相对容易做到，因为你不需要改变课程体系。但教师需要愿意放弃那些实验课上的陈旧观念。

第四：增加公共课程的数量和多样性，比如同辈主导的导论和服务活动，在这些活动中，创造性、领导力和问题解决能力可以通过有意义的项目

得到发展。

第五：我建议采用“转换式教学”模型的基本原则。

转换式教学[16]有三个核心原则。

（A）我们使用信息来促进概念的掌握。这个看似简单，但它意味着你需要让学生把他们已有的知识运用到一些新的不熟悉的信息中，而不是仅仅重复已知的信息。在密西根大学大一的有机化学课上，所有的考试题是基于教师们在出考试题前从来没看过的文献例子。从第一天开始，我们就要求学生运用概念，而不是简单记忆。你不能对学生说“你必须运用概念”，却给他们来一场默写概念的测试。记忆肯定不是唯一成功的学习方法。

（B）学生们必须发展新的学习技能。他们需要从他们的舒适区和已有的学习经验中走出来，转移到能发展新的学习技能的情境中，特别是从老师教的内容以及同辈之间学习。

（C）学生必须获得“与学习有关的态度、价值和信念”。作为一个科学教育者，我认为我必须促进科学怀疑精神，这是科学的一个重要目标。作为一个科学教育者，我们想促进批判性分析：观察事物，问自己“我相信这个论断吗？真相是什么？”怀疑精神在你的教学大纲里吗？没有！但怀疑精神应当每天都呈现，因为教师就是这样活跃的科学家，在课堂上讨论数据和实验。我期望，我们作为科学家的实践本质得到弘扬，比如怀疑精神。

如果我们真的关注教学，那很多在课堂大纲上从没出现的不同的事情应该成为课堂的一部分：适应不明确性，容忍不确定性，从失败中学习，维护论断，具有领导力。这些都是培养人才的举措，需要成为课程的一部分。尽管这些事情从来不是明确的课程大纲的一部分，它们却需要成为课程设计中的重要组成部分。这些“与学习有关的态度、价值和信念”能够帮助我们培养和识别新的人才。

中国在教育上取得了伟大成就，但更好的改变并非一蹴而就。当下，决定一些相对容易改变的事情，从它们开始先做改变，这比课程改变更为重要。管理者，教师，学生也应当改变，从采用新方法思考智力作为开始。

致谢

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（译者：李冰）

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综合性大学现代生命科学教育面临的新的挑战与要求

清华大学生命科学学院院长　王宏伟

今天我要跟大家分享综合性大学现代生命科学教育面临的新的挑战与要求。我想谈谈生命科学的未来，我们已经做到以及还未做到但可以做的事情。我希望跟大家进一步讨论如何实现教育公平，如何培养未来在各个领域特别是生命科学领域的领导者，以及大学能如何有效地为他们提供支持。

我担任清华大学生命科学学院院长，过去几年我一直在思考生命科学的现状，高等教育为生命科学改革提供了怎样的动力，尤其是在中国的高校中。以下几件事情可以与大家共同思考并探讨：第一，从整个生物学到生物学科各分支，从理论描述过渡到量化和精确分析；第二，加强子学科之间的整合；第三，加强跨学科研究，包括生物与数学、计算机、物理等领域的交叉；第四，现在生物学公众和社会影响力；第五，新媒介和新技术的应用。接下来，我将就这五个方面，来谈谈我们应该怎样把握生物学发展趋势。

首先，从理论描述过渡到量化和精确的分析这一部分主要是基于数学、物理学、统计学和计算机科学来讨论。举个例子，我两年前写的一篇关于系统生物学的论文，这篇论文中使用了很多数学、物理学、统计学、大数据分析和计算机科学知识，现代生物学不再仅是描述性的，而更多的是我们对数据进行数字化的认知，以便更准确地分析数据。现在数理归纳法在现代生物

学研究当中越来越重要，例如生物学分析的 Michaelis-Menten 等式，很多生物学学生第一次碰到这个等式，他们的大脑就当机了，但在现代生物学领域需要更多数学的运用，这就要求我们加入更多的诸如数学计算技能和电脑计算机编程技能。再比如编写代码也是生物学研究的基本技能，Phython 编程是一个非常简单并且是很多生物项目日常应用的。基于定量分析的逻辑推理也是正在发生的，还有类似更多这样生物学问题的定量观点。

另一篇论文是我应用在本科和研究生教学中，关于如何使用定量的方法来分析随机基因组输血中的细菌理论，这篇论文的背后包含了有很多新科学。这是我们大学一位叫 Sunny Xie 十年前提出的，对于我们用定量的方法来思考生物概念和随机事件现象仍然是非常有用的。现在我们很多高校也开始注重生物科学和不同学科的交叉，强调数学、物理、计算机科学等学科课程设计的更新，引入统计学、概率论、线性代数、随机过程、非线性动力学等。虽然在本科一二年级的生物学学习中，仍然需要学习数学、物理、化学知识，但是很多老师仍在使用百年之前古老的教学理论，而不是现代生物学的发现。因此，不仅仅是生物学，生命科学中也需要应用到更多新概念，例如统计学、概率论、随机过程和非线性动力学。我们应该在课程设计中引入更多的生物问题，让老师教授数学、物理、化学、计算机的同时，也使用生物学研究的内容进行教学，不仅是使用常见的数理教学的例子，同时也在生物学课程中引入数学推导和定量分析。

第二个我想强调的是当代生物学是各学科的整合，因此我们开始尝试在生物学中使用更多从微观到宏观的全谱。科学问题从分子到个体甚至全体都是不同层次的，同时要共同开展体内和体外的研究。在生物学中，我们会使用还原论与整体论结合作为一种方法论，推进各种方法的全面广泛的应用，也希望实现各种方式关系中的创新。

我们学院的一位同事在使用单细胞技术来研究单分子抗体受体，他们从研究全球人类中不同人群基因组差别开始，来定义不同种群可能有的不同的进化，然后他们进一步细化到分子级别，来看看为什么不同群体对人体免疫

有不同的反应。理解人类进化对人类有很多帮助，生命的研究已经跟随着人口，甚至进化和生态前进的尺度不断发展，都是在我们研究范围之内。

现代生物学课程也引入进化论、物种多样性和生态学的新概念，这也是分子生物学和生物化学方面需要涉及的内容，同时在分子生物学、细胞生物学的最新进展和发现也需要在普通生物学与生态学课程中加以介绍，这对于从分子水平理解生态学也非常重要。同时，随着该领域越来越多的合作机会，我们还需要努力去减少学科和专业间的限制，解释生物学重大发现背后的逻辑和推理过程，而不仅仅只告诉学生“这些是你需要记住的发现”，要让学生了解背后的历史，科学是如何形成的，这也助于学生理解逻辑和背后的故事。我还清晰地记得我在大学时，从一位物理学教授那里学过一门课，讲 20 世纪现代物理学发现，我从那里得到的不仅仅是记住了发现的最终结论，而且还了解这个关于宇宙力学以及相关理论的重大发现是如何产生的。

第三，跨学科研究是现代生命科学发展的动力，如果你了解现在生命科学的构建，会发现尤其在二十世纪四五十年间，很多科学家来自物理和化学背景，他们的研究是当代生命科学的主要驱动力。现在生命科学使用的工具很多是由物理学家、化学家、计算机科学家所研究出来的，甚至是工程师开发的生物学工具。现代生命科学一方面是由跨学科研究领域推动的，另一方面是非常复杂的现象，甚至是最复杂的现象。生命科学也成为许多其他学科的主要推动力，包括物理学、化学、甚至向一些数学家展示我们如何用数学理论和方程解释复杂的生物现象，并且创造新的理论。在生命科学领域，我们也需要其他专业专长，比如在清华生科院，大概有 70 个研究员，有三分之一本科都不是生物背景，而是来自物理学、化学、甚至机械工程、计算机科学。因此，生命科学领域需要招募各行业人才，也需要创造新的学科概念。

在化学生物学、物理生物学这些生命科学领域发展起来的前沿学科的出现，意味着需要具有跨学科沟通能力的生物专业学生，所以我总是鼓励学生去与其他学院或者隔壁宿舍不同专业的学生进行谈论。在清华，相同学科的研究生不住在一起，反而同宿舍的同学可能来自计算机或者人文学科，以此

鼓励学生互相交流，这点很重要。当我试图向一些非生物专业的学生或科学家传递一些信息时，比如向他们传递我的想法，同时也要能理解他们说的是什么，这样才可以互相达成共同的价值观，共同进行头脑风暴，为生物科学创造新的内容，这就是跨学科交流的意义。

冷冻电镜技术在过去的几年中已经成为生物学研究中一个非常强大的工具，它不仅能解决生物模型细节问题，帮助我们看清堆积在非常复杂的生物分子中的项目。这项技术是经过许多物理学家、数学家、计算机科学家和工程师多年来不断研发。所以，这是一个过去五年里彻底改革的冷冻电镜的例子，它被称为新探测器，是高能粒子物理科学家和半导体工程师共同完成，这个工具可以拍摄冷冻标本图像中的小分子——这些是人们使用探测器看到的病毒。所有这些硬件和软件都是由物理学家、工程师、计算机科学家和一些数学家开发的，而不是生物学家。这也进一步说明生物学是跨学科的。在2017年冷冻电镜的诺贝尔获得者中，三位先驱每一位都没有生物学背景，他们受过物理和化学专业训练，但是他们在生物领域做出先驱性贡献，应用于许多重要的生物学机制和理论学科，让所有生物学家都能从中受益。

我的学生统计了过去30年与生物学相关的诺贝尔得主，他们中的许多人在四五十年前上过大学，一半本科学习生物或医学，另一半来自数学、物理学、化学和跨学科背景。尤其是当你想做基础诺贝尔发现，不得不说生命科学是一个跨学科的领域。在生物学教育中，我们应该为生物专业的学生量身定制与其它学科相关的课程，为生物学和非生物学的学生提供跨学科的课程，搭建一个广泛而深入的跨学科交流和讨论平台。现在我们确实有一些非生物背景的老师来教生物学生学习数学、物理学、化学课程，而且要求他们首先要以第一专业的教学方式，其次也要以使用生物学背景的教学方式，这就需要其他学科老师更多地跟生物学老师沟通，讨论和制定课程内容，以更高效的教学方式教育学生，让生物学的学生了解为什么要学习数学、物理学、化学这些学科了。

第四点，生物学已经成为更具有公众影响力和社会关注度的学科，包括

当代生物技术产业化。我们开始意识到生物学的重要是因为大众对于健康、食品安全和环境质量的认识提高，需要我们进行生物科学方面的公众教育，对生物学专业人员的社会、人道、法律能力也有更多要求。

几年前有个关于转基因作物的课题，转基因对于小鼠肿瘤增长有促进作用，甚至公众开始讨论可以饿死癌细胞。所以现在有很多相应的话题与人类健康及食品安全相关，也经常成为媒体关注的头条。有些公众因为其不具备专业知识，来评判新闻的真伪，很容易被误导。随着生物学在社会上的影响力越来越大，生物学应该成为通识教育的一部分。我也向清华大学校长传达了这一信息，现在清华也正在努力将生物教育纳入通识教育当中。我们鼓励生物学背景的学生进入到不同的专业领域，包括政府、立法、甚至媒体。我们也需要推进大众生物学教育，希望能引入新媒体和新技术，比如应用在线媒体、在线技术、动画技术、虚拟现实技术（VR）来进行教学和学习。举两个例子：第一个是在清华慕课推出的“普通生物学”课程，同时我本人也参与到 VR 技术开发，我们开发了一个用 VR 来进行微分子层面观察的技术，好比把自己放在整个分子世界中观察，通过这种方法来进行本科教学和研究生教学。现在我们正在做一些试点测试，希望将来能在课程中采用这些方法。

在清华，本科教学过程大多数仍然以教师为中心，很少讨论和互动，课程设计上也缺乏最新的发现和突破。对此，清华开始试点，其中一个清华学堂生命科学项目，与交大致远学院类似，我们招收了一批对研究特别感兴趣的学生，课程的设计和选择不局限于学校规定的课程，有更多灵活性。学生需要学习四门主要课程：《生命科学研究的逻辑学》、《学术方法》、《科学英文写作》和《科研培训》。在实验室第一年，或者本科第二年开始做研究，学生可要求豁免课程，我们也鼓励他们选择跨学科课程。学生有机会去国际顶尖高校交流，例如密西根大学、斯坦福大学、多伦多大学和剑桥大学，他们参加实习项目或者论坛，我们也邀请到诺贝尔奖获得者来清华讲课，通过参加开放的实验室会议和期刊俱乐部，让本科生参与真正的科学研究。同时，我们也设计一些创新型课程，比如数学、物理学和生物化学，还有癌症生物

学、干细胞生物学、化学生物学和现代生物技术，这些课程向本科生和研究生都开放。

清华有代表队参加国际基因工程机器大赛，近几十年来，我们的本科生积极主动地学习生物学课程和一些研究技能。我们也不断开拓联合办学项目，与哈佛大学、剑桥大学建立暑期实习项目，鼓励学生去对方高校实验室进行科研实习。毕业前有的学生已经累积了三到四年的研究技能，整体研究可以做的非常好，能够以第一作者或者共同作者发表文章。

清华大学还有一个项目，虽然不是新项目，但是我们两年前才迎来第一批毕业生，实际上这个项目大约十年前就开始了，这就是清华大学的医学教育项目。在八年长学制医学教育过程中引入两年海外科研训练的课程体系：从大一开始在清华学习三年，之后两年在国外学习，有些还会去澳大利亚实习，最后一年返校进行临床培训，最终获得医学博士学位。这个项目能够帮助学生获得医学教育经验和研究背景，我们希望能培养出下一代优秀的中国医学科学家。

（译者：林依洁）

“好奇心驱动”的拔尖创新人才培养探索

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人类和社会发展正面临着多重挑战，包括生存挑战、安全挑战、发展挑战、繁荣挑战，无论是从能源，还是从种族、战争，以及健康需求，还有科技水平的发展，给人类造成了很多问题；因此，大学的使命应该是：培养可以面对未来挑战的拔尖人才。另外，从新一轮的科技革命，即我们称之为第四次科技革命，可以看出它区别于以往三次科技革命的特征，具体包括：颠覆性、突发性、集聚性、交融性，它的规模、广度、复杂度都远超以往的科技革命。未来的拔尖人才培养应该可以为学生培养足够的责任心、能力，来应对科技革命带来的挑战。在我们熟知的一些领域，如自动驾驶、人工智能、互联网 +、可穿戴设备等，都在历经一些前所未有的革命性变化。

第四次科技革命，给我们带来了新的改变，首先是在思维范式上的变化。第一次科技革命是由思想革命和文艺复兴带来的，西方的启蒙思想促成了第二次技术革命的发生，第三次科技革命仍在进行，我们现阶段重点研究的则是第四次科技革命。传统的思维范式在前面三次科技革命中以“重视经典的精确因果关系”模式呈现，从被动生存的“实验归纳、采集数据”，到主动探究的“模型推演、解析工具”，到有边际好奇心的“仿真模拟、计算工具”，到无边际的好奇方面的“数据采集、挖掘”，再过渡到当下热门的“互联网、大数据、AI”。其中，新思维范式的一大特点是量子力学提出的“概

率因果论或整体因果论”，并由此过渡到大数据强调的“万物相关性联系”。因而，未来的创新人才培养工作需要新的思维范式：要能从海量、多维、完备的大数据信息里发掘关联关系、创造新知识。

近几年，科研人员曾预估2025年前人类社会将出现新的引爆点，它的一个特点是它完全打破了传统、单一、分割、独立的知识体系，指数级增长的新知识互相融合改变知识结构。对于大学的人才培养，尤其是拔尖人才培养，应有新要求，即未来的创新人才不仅需要具备全面系统的知识储备，还需要对动态发展的知识体系和爆炸产生的新知识进行再认知的能力。上海纽约大学校长Jeffrey Lehman曾提到，人类的传统三段式成长，是从教育到工作到退休，未来这可能发展为五段式，甚至是八段式。以纯碎完成学习、工作、退休为目标的发展模式将不适应新的社会环境，人们还需不断再学习，比如到45岁左右重返学校学习，或进行自学。19世纪时期，人类的平均寿命为四十岁左右，现在已经到八十岁，未来可能到一百岁，因而无法把学了十年的知识一直用到退休，所以，学习时间也需要随之进行延长。学习能力是与知识结构变化、科技革命的产生，以及万物互联的关联紧密相连的，我们需要指导并提高学生对新知识体系及结构的再认识、再学习的能力。

第四次科技革命带来的一个重要的颠覆性挑战和变革是它会广泛的改变我们的生活方式，比如我们的出行、衣食，以及思想方式，这些将有利于促进国家、社会中各层次变革的形成；然而，我们不应忽略其带来的另外的变化。由于知识结构和科技变化在广度、复杂度、规模、速度方面的发展迅速，因而，系统性变革将造成垄断、寡头的产生，国家和产业间的竞争日益激烈，贫富差距继续拉大，以及更多不平衡现象的产生。因此，人才培养工作必须注重加强对学生多元文化理解和全球视野方面的能力提升，学生需要更强的包容心，才能从容地应对新科技革命带来的变化和挑战。

好奇心驱动的学习探索，可以总结过去科技革命的一些成功经验，比如：第一次产业革命纺织业及蒸汽机的变革，第二次科技革命中以汽车及电力为代表性的革命及技术，第三次科技革命中迅速发展的计算机和核技术，

第四次科技革命则包含了万物互联、人工智能、基金编辑、燃料电池。而这些变革的底层根源是理论的发展，它带动了科技和产业的变革。

理论的发展是如何产生的呢？图灵奖得主、康奈尔大学的 John Hopcroft 教授曾谈到，理论的发展源于基础研究，它是发散性的；而这又要求人才通过强烈的好奇心对未知世界进行探索，这样才能带来理论的突破，而不是对单一目标科学计算的探索。即，突破性的研究往往是基于一个或一群人的探知未来的强烈好奇心。总而言之，人类的好奇心，就是历次科技革命的根本驱动力。为什么好奇心如此重要？好奇心是创造潜质人才的一个特征，即一个人是否有创新能力与其好奇心紧密相关。以爱因斯坦为例，他讲过“I have no special talent. I am only passionately curious”。好奇心是认知世界的原动力、创新行为的持久力、是创新特质形成的驱动力、科学研究的驱动力。因此，探索实施“好奇心驱动”的创新人才培养模式是致远学院的建院理念以及一直以来的人才培养方式。

上海交通大学在人才培养的“好奇心驱动”模式包括三部分：第一部分为“梦起思源”，即我们的理念来源；第二部分为“思源筑梦”，即具体实施方式；第三部分为“致远逐梦”，即探索未来的规划及方法。致远学院的创建可追溯到 2008 年，当时张杰院士、鄂维南院士，以及蔡申瓯教授，在交大美丽的思源湖畔探索如何来培养未来的一批科学精英。他们三位都是理科领域的大师级人物，并有非常大的国际影响力。当时张院士担任交大校长，主要想法聚焦在如何培养一批未来的科学大师。当时的一个设想是，精选出一批学生，给他们最好的教育。交大目前仍然还在秉持并践行着这个传统。林校长提出，希望我们的学生可以“不出国门，就能享受世界一流的高等教育”。传承着交大的特班精神，我们在 2009 年时创建了“理科班”，首届只有 29 名学生。基于“好奇心驱动”这一理念，并参照英国教育家 Newman 的倡议，我们把一群极具创新思维的教师和一群极具创新潜力的学生聚集在一起，让他们的创造力互相激发，从而产生让学生受益终身的创新能力。

致远学院的一个具体实践是邀请了图灵奖及‘中国政府友谊奖’获得

者，致远计算机科学方向首席教授 John Hopcroft 指导我院学子。John 提到，“学生和教师互相成就学术声誉，我的学术成果都是和我科研工作初期那些博士生一起获得的，如今他们大部分都成为了院士级科学家。青年学生是极具天赋的，青年教师和他们天天一起交流讨论，才能产生最前沿的学术思想。”致远学院特别注重本科生的培养，而培养好奇心是学生们成为优秀博士生的必要基础和前提。2010 年，致远学院正式挂牌，为了响应当时教育部对拔尖人才培养的目标，学院致力于培养“具有家国情怀、批判性思维、知识整合能力、沟通写作能力、多元文化理解和全球化视野的创新型领袖人才”。我们的具体目标包括：毕业生达到国际一流大学 Top10% 学生的水准；10 年后有一批毕业生能够在国际一流大学任教或在顶级研究机构从事科学研究工作；20 年后有若干学生成为国际学术大师。

在交大范围内，致远学院不断吸引校内投身科学研究，并追求人生最大价值的优秀学子。2014 年，我们在全校范围实施了致远荣誉计划。该计划不仅涵盖了理科专业，还辐射了我校的主流工科专业，我们希望持续提升致远特区的办学成果和模式起到的辐射作用，对交大的人才培养起到示范作用，也希望致远精神得到倡导和传播，不断促进学科之间的融合和交叉。致远的主要任务包括：传承交大历史，培养“一流人才”；回归大学本质，答钱老之问，培养拔尖创新人才；支撑学科建设，振兴交大理科，助力工科发展；注重全人教育，关注人类生存和发展的重大问题，最终把这些目标贯穿到人才培养的工作中。

“好奇心驱动”的人才培养模式具体实施方式包括三个体系：好奇心驱动的学习体系、教学体系、科研体系。三个体系相辅相成，对学生来讲，在激发其好奇心方面，在大师的引导下，以科学问题为中心，激发学生对科学的原始好奇心，推动学生进行自主探索以寻求问题的解决方式；在呵护学生好奇心方面，我们引导其在自主认知的时间过程中，经由失效与挫折，通过努力最终获得成功，体验乐趣，以此逐渐巩固成就及动机。具体来讲，课程方面包括三个方向，即使命驱动，面向国家重大需求及人类重大挑战；兴趣

驱动，大师引领的科学研究、同伴的互动，自主选择及主动学习相结合；能力驱动，通过思维训练搭建科研创新平台，让学生在科研的过程中锻炼和认识自己的能力，从而激发对成功的渴望，并不断提升自身的科学素养及人文情怀。

从大学一年级到四年级，致远的课程也在不断的建设和完善，我们将基础、通识、专业课、荣誉、交叉、前沿等课程建设为荣誉课程，即教育部提倡的“精课”。在一到四年级的学习过程中，我们开展了进阶式的科研实践、学术竞赛体系，通过科教融合、大师引领、贯通培养，为学生们未来追求学术做好准备。接下来的示例是我们 17 届化学方向的学生林云霄，他在本科毕业后选择加入致远博士荣誉计划。贯通的培养方案，使其提前进入博士生的阶段学习，本科期间打下的牢固科研基础和高强度的海外训练有效地帮助他快速地进入研究状态，第一时间确立完整目标。由此可见，致远学院让林云霄本科期间接触科研、主动科研的做法，对他未来成为一名研究者奠定了坚实的基础，也帮他有效地确立了自己的研究目标。在知识及课程体系方面，我们也在实施通专交融的整合式培养。我们在学生基础知识的学习方面，按四类学科进行分类：物质科学、生命科学、数据科学、人文科学，希望学生未来在这四个领域的学习中能够习得核心知识体系以及交融和交叉之间的关联学习。在学习基础知识方面，夯实数理基础，即加强数理课程的学习；注重学科交叉，即各学科思维方式研究方法的探究；加强通识课程，即对人文情怀及跨文化能力的培养，最终选择自己的专业发展、开展自主研究，规划自己的未来。接下来介绍的是第一届数学方面的毕业生殷佳祺，她一开始学习了其它专业，后面根据个人兴趣转至数学专业。学生提到：“正因为致远，我才可以跌跌撞撞反反复复认清我的路，找到我珍惜的，并愿意去追逐的东西”，她目前正在海外知名学府攻读博士学位。

师资方面，目前已有超过 400 位教师参与到致远学院的教学工作，其中，教师团队包括 105 位的海外教师，致远为本科生开设了 1167 门次专业课程。我院为学生提供了非常豪华的课程表，邀请包括诺贝尔奖得主、图灵奖

得主、中科院院士、以及各类讲席教授在内的专家及学者为学生授课。诺贝尔奖得主 Tony Leggett 教授多年来持续为致远学生授课，学生曾说到：“Tony 点燃了我对科研的兴趣与热情，他对科学的热爱和对教育的敬业精神，让我们深刻体会到物理学的魔力，也更加明确了自己的科研方向与梦想”。由此可见，学生在这种跟大师交流和共同科研的浸泡式的学习模式深深地促进并激发了其自学精神，且进一步影响其未来的科研目标及志趣。致远学院的科研体系得益于学院和交大自然科学研究院之间的互动和交流，我们跟自然科学研究院共享了物理空间，形成了言传身教的育人环境。自然科学研究院有一批年轻的杰出青年学者，他们在加入研究院的初期就开始教授致远的学生，他们担任班主任、导师、给学生授课，由此，学生得到了非常深入且全方位科研才俊的言传身教的浸泡与熏陶。致远创新人才培养的另外一个特点是以专业为基础的项目主任制。项目主任们是学科兴趣的引路人，是学生身心发展的贴心人，他们都是学者型教授，教学经验非常丰富。他们是国家级或市级教学名师、国家杰青、长江学者等著名学者，对人才培养及好奇心激发方面有着成熟有效的经验及措施。例如，数学方向的项目主任王维克教授，建议致远开设“科学思想背后的‘小故事’课程”。他认为：“经典的科学故事就好像活水，我们何不以故事的形式，带着孩子们重走科学家的发现之旅，点燃他们对科学研究的热情呢？”，他建议通过非常活跃的课堂教学来点燃学生对未来科学的兴趣和目标。同时，我们也邀请了各领域的学术大师，开设 1200 余场科学技术、人文社科方面的致远沙龙、学子沙龙，由此使学生获得与教授们面对面及跨学科的交流学习机会。学生们对此表现出浓厚的兴趣，每周三下午都会准时参加沙龙和讲座，也通过对各类学术报告的学习，全面激发了自身的科研兴趣。

接下来是另外一个学生培养示例，物理方向毕业生谈安迪通过在致远学院的熏陶，跟随讲席教授季向东教授读博，并在世界上最深的地下实验室探测暗物质，现担任“PandaX-II 的负责人”。学生说，“当我在本科阶段第一次听说暗物质研究的时候，我感觉它有一种魔力深深地吸引着我，如今我已在

中国锦屏山地下实验室从事了六年多的暗物质直接探测研究，我终于发现，其实这样一种魔力是源于内心深处对于自然界最强烈的一种好奇心”。由此可见，致远学院把学生对科学和自然的好奇心充分调动起来，使他坚持在地下实验室开展了六年多研究工作。

从一年级到四年级，致远学院建立了完整的进阶式的科研和训练体系。通过一年级的大创、实验课、实验室轮转，到海外研修、ZIRC 学者项目，再到毕业论文、学术竞赛的进阶式训练，形式一个完整的科研训练体系，学生们可选择自由参加。接下来介绍的学生示例是首届致远毕业生黄金紫；他因关于“一根棒棒糖可以舔多少次”的研究荣获了 2015 年获得了“菠萝科学奖”数学奖。看似有趣的课题其实蕴含了很多深刻的科学原理在其中。黄金紫提到，“我是一个很不坚定的人，但是很幸运，最终我还是回到了我所喜欢的事业上”。他在致远找到了自己真正的目标和方向，并通过实验室轮转：激光等离子体实验室、计算神经学课题组、流体力学实验室、柯朗研究所，最终找到了自己想做的研究内容，也得到了初步的研究成果。

致远从 2015 年开始创建致远创新研究中心，其目标是帮助学生以学者的、跟教授们平等的身份来自主设计、研究自己的科研课题。中心的四个前沿方向包括大数据、新能源材料、生命科学、量子通信和计算，学生可自主选择感兴趣的平台。他们从一年级开始认识科研，到主动科研，到以学者项目形式来体验科研，可助其对科研有个完整的认识。致远还给学生提供了“WOW”平台，即使学生以一个惊奇的态度激发其好奇心，鼓励学生从“众所周知”的‘大问题’中产生兴趣和灵感，树立“问题意识”。接下来介绍的例子是工科方向王子昭，他当时在 ZIRC 中心完成了学者项目，并在项目研究期间参加了 U21 大学联盟全球创新挑战赛，荣获了有史以来中国高校拿到的最高奖，目前他在哈佛大学攻读博士学位。

好奇心是分层次的：感性阶段，即好奇心，是对周围事物的探索、好奇、兴趣；理性阶段，即强烈的好奇心，是探究新奇或未知的内在需求；高级阶段，即持之以恒、强烈的好奇心，对构建人类命运共同体、振兴中华、

民族崛起进行关注，这种好奇心其实是一种使命和责任；在此阶段，人们将有一种强烈的使命感来专注地做好一件事。对于命运共同体，人类需要远离恐惧、构建普遍安全的世界；远离贫困、构建共同繁荣的世界；远离封闭、构建开放包容的世界；同时也构建山清水秀、清洁美丽的世界。这些追求都可成为未来好奇心驱动的人才培养驱动力。此外，在培养持之以恒、强烈好奇心的过程中，我们也注重跟境内外大学的交流，跟世界顶尖高校进行互动，即加强学生跨文化能力的培养，使学生对中国和世界文化进行深入的认知及了解。

学生在致远学院会成长为有独立思想、独立思考人格的人，他对事物的看法不是人云亦云，即他们明确自己希望做什么事，希望未来成为什么人，也会增强他们关注和帮扶低年级学生的热情和耐心。致远的拔尖人才培养模式在国内外受到了高度认可，并在国内外多次荣获教育类奖项及殊荣。

世界一流大学的使命，包括需要产生颠覆性的科研成果，来引领未来科技的发展，但这不是我们的根本目标。做科研的宗旨是使学生有机会接触到前沿科学，通过推动人类社会经济的可持续发展来培养领袖型杰出人才，以促进全球的共同繁荣。我们希望学生们用好奇心来撬动地球，对构建全球人类命运共同体做出上海交通大学致远学院应有的贡献。

（译者：范文芳）

三、圆桌讨论（中文）

专家座谈

今天我们已经有 8 位重量级专家做出了深度报告，内容覆盖了学生培养的方方面面。汇报讲到了中国美国高等教育的培养方式，多元文化有效性的培养，整个信息时代的培养模式，法国高等教育模式，新加坡教育模式以及美国教育模式。同时我们还有一个报告涉及工程教育，阐述到底该做人才的发现还是人才的选择。人才的教育本质上是关于好奇心驱使的培养模式。我们已有很多讨论讲到了人才的培养模式，当然我们仍然还会有一些问题留下来，可以在小组讨论的时候进行进一步讨论。

章俊良

我们应该怎样助力教师成长，让他们更好地进行人才的培养和教育？针对我们的教师，他们应成为培养人才的主力，我们学校有很多管理层人员，都是具有丰富的经验，我们应该帮助老师提高教学水平，以更好地选拔和培养人才。尤其是 Joaquim Nassar 教授，他在整个新的学生教育和培训方面已有 30 多年的历史，所以我们先从最右边的嘉宾开始整个问题的回答。

Joaquim P. Nassar

我认为这是非常广泛问题，我的主要关注点是一些青年教师，怎样帮助他们进行成长。之前提到了一点，其实获得的东西只有在衡量之后才能够了解它的结果质量。因此，我们需要有量化的一个评估标准。如果我们关注了教学的一个任务，例如在法国，我们的教学任务是以小时来计算的，年轻教师大概需要有 196 个小时的教学目标，当然这并不是能够鼓励教师有创新性的教学方法，我们只是一个面对面的教学小时数的统计。当然这个小时数的要求很高，需要花时间去准备课程、小组讨论、个人辅导等相应活动。因此，从实际考虑，我们应考虑从学生学分的角度出发。学生的学分并不一定是以小时测量的，而是应以学生的工作量来计算，进而最终我们以学分来记录，这样我们就有更多的自由度，从而让更多的教师可开展教学方法的调整，比如小组讨论、小组互动。我们现在按教育模式分组的教学不常见，当下主要以大班为主，我们鼓励开展更有个性化的教学模式，能够针对某些课程呈现更高的灵活性，可以根据老师的喜好去调整，比如有些相应的教学项目，可由几个老师一起开发与设计，比如跨学科设计一门课。

苏重豪

我想分享新加坡的一个经验给大家，新加坡国立大学有一个教学中心 (教和学的中心)，年轻教授一般去中心参加 3 周的课程。教学中心有很多不同类型的课，传授给年轻教师应该和不应使用的举措，中心会邀请有丰富经验的教授分享宝贵教学经验，例如如何准备教学模块。年轻教授会开展一些带有研究性质的教学项目，涉及到教学方法尝试并基于此总结经验，获得全新教学方法的优缺点，并进行修改。其次，助理教授辅助主教授，主教授是最有经验的教学负责人员，也会去开展研究项目来指导与培养助理教授的。

Ramon Wyss

我们的院系是我们教职员工的最主要的家，我们需要有一个机构性的支持，因此构建良好的院系环境很重要。首先我完全同意刚才两位专家的观点，我们需要去支持年轻教职员工的研究技能培养，这也是我们现在正在做的。此外还要设置一系列价值观的标准，比如一个院系的哪些特质最重要等，还要确保有一个共享的价值观。当然，我们是一个很大的公立学校，因此我们在一开始的新人阶段，所有的课程都有好多来自不同阶段的学生参加，我们不可能让一个年轻老师一个人去面对这样一个班级，我们一般都是用一个团队来开展新生的教学工作，我们也有很多资料可以分享给年轻老师，包括我们的教学策略、方法、我们非常希望年轻老师能够尽快成长，同样我们也希望他们的研究项目也能够尽快成功，所以我们的教学或指导是很自然的。比如年轻老师和我一起教学，那我们会经常讨论我们的教学预期及目标。因此我们不会单独把年轻老师丢在一边不管，而是推动他取得成果。比如有个全新的助理教授，在第一学期后进行教学打分，院系会给年轻老师指派一位有着 30 多年教学经验的老师，这样就不会出现教学事故，所以，院系是我们每位老师的家。第二点是开诚布公、透明公正。第三点是关注指导师生的关系。我们很希望年轻老师成功，会投入大量资金培养老师，希望老师可以一直跟着往前走。

章俊良

同样问题换一个思路去问，您是副校长，我的问题是应该如何评估年轻老师的表现，研究任务、教学任务，如何晋升、提升工资水平，如何去评估，比如有些老师可能教学做的非常好，但可能在研究方面很平庸，或者有人反过来。如何平衡教学、研究两个点，哪些特质对年轻老师未来发展很重要？

Brian Coppola

我觉得我并不一定合适回答这个问题，因为我负责国际关系，但是可以就我们大学一些做法进行分析，比如有些教学与新知识研究。当然教学第一，研究第二，第三是社会关系的建立。我们特别关注和社会互动的关系，我们做的研究不能闭门造车，我们必须和社会产生关系，当然我讲的三点都是职业生涯非常重要三个点，是老师转正非常重要的。这里教学工作占了很大的比重，因为教学能力较易衡量，研究水平则可以通过论文引用与发表数量来衡量。年轻教师有专门的教学法，主动去学习并开发新的教学法。同时，作为学生评估的一部分，每一位老师都有一个教学法的跟踪档案，我们通过他们教学法的有效性进行跟踪与评估。作为教师，自己的职业发展是看教学法是否有相应进展而决定的，我觉得这对于大学非常关键，我们以强调教学为主。

王宏伟

我必须承认，现在所有顶尖的中国大学，都不够重视本科教育，其实中国作为发展国家还有很多需要改进的地方，包括清华、交大，之前有提到，我们主要没有特别关注研究，但是我们希望人做出更多的研究。现在我们的管理、学术以及论文发表都有更多的信心，但是最重要的还是对于高等教育的优化，对于新一代科学家人才的培养，对未来世界领导者的培养，所以教育是非常关键的。我非常同意前几位专家关于教育的理念，他们都讲到我们教育的评估是至关重要的，从今天上午我们看到的两个照片，我感到我们对于教育的研究、评估已经回到了大学的教育该如何评估这样一个重点，关于大学，我们需关注每个学院每个学科该如何评估。对于学院，该去思考教职员工如何评估，现在很多评估可能过多关注于他们的研究水平。我认为不应过度关注研究水平，研究应只占很小的一个部分，应该更多关注他们教育、

教学部分，以及在教育方面的实践。这是我们需要做的事情，需要去努力地完成和优化。在清华，我们也意识到了这样的问题，越来越关注教学质量的提高，未来教职员工尤其年轻教师晋升的评估很大程度是分析教学方面的表现，而不是进一步去强调他们的研究能力、论文发表能力，我们关键关注的是教学能力。更重要的是，不应在年轻教职员工身上给他们太多的教学压力，因为这样是错误的，没有任何帮助。其实学生在课程后的表现才是我们需要关注的，而不是计算教师在教室上了多少学时，上了多少课。

章俊良

感谢王教授的观点，我相信清华在这方面是有独到见解的。这是我的第一个问题，我的第二个问题是，在中国有这样的术语来描述人才的培养方式：圈养和散养。更详细地说，一个是根据每个学生的实际情况提供最有效的教育，强调每一个特殊案例，另一个是选拔相同专业的人才，给他们最好的教育。但是在今天上午的讲座中也提到另外一个观点，这种选拔人才的模式不能忽略其他学生，虽然这些学生的基数大而导致能成为拔尖创新型领袖人才的比例相对低，但是教育的初衷就是不能忽略任何学生，而应该给他们同等的机会。就这一难题，我想征求大家的意见，我们应该选择何种方式？

徐学敏

圈养和散养相比于荣誉计划内，学生是应该在一起学习或者分散到各个学院。

Joaquim P. Nassar

就我看来没有固定的答案，优秀的项目不管是住宿制还是非住宿制，都

需要不断发展，并确保拥有不同才能和兴趣的学生能够在他们一生中选择不同的职业。 几个世纪以来，法国的大学都有一些学科对所有学生开放，还有一些课程限制了年龄段或者设置了选择性强的入学考试。有一些优秀的学生通过了考试并在他们 20 多岁时就确定了未来发展道路，而有些可能需要花更多的时间，也许是还没有准备好，也许是还有其它兴趣，或者有家族传统，在最终决定之前，他们可能需要工作几年，这些学生也是有潜能的。我认为一个体系需要激发学生在不同年龄阶段的潜能，能够重新指导他们在未来职业规划中获得更多的优势。所以不管是圈养还是散养，都需要保持开放的模式和氛围，确保学生有决定的自由和权利。

苏重豪

我来分享一些新加坡经验，新加坡高校为学生提供了多种选择，我们也有寄宿学院，很多学生住在一幢宿舍楼，通过良好的形式和完整的课程，他们以一种有趣的、多学科的方式学习。我们还有一个“科学专题项目”以及“大学学者项目”，“科学专题项目”包含了所有学科，“大学学者项目”结合了所有不同的学科，艺术家、科学家、律师都在同一幢楼里，在同一个屋檐下研究。除此之外，我们也设有专门针对还未发掘自己才能的学生的学习方式，这些学生可能在早年间并没有发现自己的才能，可是在未来几年他们会找到自己擅长的事，我们也要允许这些学生继续成长。我认为大学应该提供多途径、多渠道，这样才可以找到更适合学生个体发展的方法。

Brian Coppola

这个答案是变化的，我想强调两件事，第一我始终相信开放式解决方案，但它对正确的环境有要求，如果在错误的环境中采取开放式解决方案，是无法取得成效的。确实有一些本身就很优质的寄宿项目，但我确信这并不

是因为住宿项目本身，而是归功于学校的名声，因为好的学校才有学生愿意去，这是一个自我认同的地方。密西根大学化学研究生院是代表性项目之一，你只能在实验室做化学实验，而不是在家里。前 25 名化学系的 60% 的教授都是有伯克利博士或博士后学位，该项目的成功并不是因为他们有很好的项目，而是归功于学校出色的声誉，才可以吸引学生来选择。

大家去看看那些最成功的寄宿项目，比如牛津大学、剑桥大学，这些项目之所以成功是因为学校有享誉全球的声誉，好的学生愿意去，因此越来越好。我认为它拥有所有等级，不论开放式、封闭式，是否住宿制，或者四者均有，在于你所处的环境有多独特。我不认为工具是永远的解决方案，我也不认为寄宿项目是答案。

Ramon A. Wyss

当我大约二十八九岁的时候才进入大学，在这之前我在车间工作并且需要先完成高中学业。瑞典的制度非常开放，基于自己的信用和兴趣，人们到 30 岁的时候还能进入大学学习。最重要的是，每个人或多或少都有一种天赋，而识别自己天赋的技巧需要多次错误的选择之后才能遇到正确合适的选择，这需要整个社会的开放性，使之能够接受 100 年来的任何变化。技术发展如此之快使得我们需要终身不断学习，并且始终保持开放的心态，你可以在换工作或者做其它事情的时候明显地感受到这些，这对不同学科产生了重大影响。 所以我试图提高效率，寻找其它机会，提供一些东西，比如录取、面试录取、不同的人的录取。我认为，你融合得越多，就越能打造一个让创造力蓬勃发展的环境。

Hongwei Wang

我举两个例子：第一个，在清华生命科学学院有一类严格的学堂，学生

不是在进入大学后立刻分班，而是在第二年或第三年申请并在面试中讨论，他们不会进入特定的宿舍，仍然和其他同学一起生活。这门课让选课更加灵活，也能探讨更多学科问题，氛围非常开放，学生如果觉得某些课题没有针对性或者表现不达标，可以申请退出。目前看来这个模式是成功的。所以我希望能够提供给学生们更开放式的环境，，而不要与其他学生分隔开。与此同时，普通课堂的学生也会有意向加入。

第二个例子，我们有针对八年制医学学生项目的环境测量，学生们更多地加入为医学科学家设计的项目中，他们有自己的目标并且跟班级目标一致，因此更有动力努力学习、工作、做研究，并保持这个习惯，所以这是一个特定目标的优势。我们希望学生未来成为什么样的人？如果我们有像医学院项目这样的具体目标，那么就按部就班地实现，但是如果我们是想培养出更多思想开放的学生，我会更偏向开放的环境。

章俊良

因为本科教育只有四年的时间，在短暂的时间里，我们应该更重视打好专业基础还是培养科研能力？作为教师应该如何平衡这二者？

Hongwei Wang

从我个人的角度来看研究和教学之间的平衡，我很喜欢教学因为教学是一个有启发的体验，就像之前提到，教学是按时间来的，我也是通过教授学生而学习的。在教学过程中学生不断提问新的问题，也使我重新思考教学主题，我认为这是一种自我教育的反馈。每当准备教学材料时，我会产生一些新想法，对我的一些研究项目的思路也有启发，教学和研究二者是相辅相成的。

我认为对学生来说这二者一样重要，至少在生物学上是一样的，因为生

物学本身就是一门实验科学，所以一旦学生做实验，其实就在做研究。大部分学生的主要知识与批判性思维都是通过实验培养出来的，清华大学非常鼓励本科生做研究，我们甚至通过增加实验课程的学分来激励学生。

Ramon A. Wyss

还有几个重要的方面需要考虑，我来分享我大学的内容。我入学的时候，大学是四年制，但是学生平均可能学习六年甚至更久，因为每位教授会在他的领域加入更多的学科内容，课程数量不断增加，校长不会干涉，但是我认为院长或者校长级别的学校领导应该来控制课程内容。比如我是一名化学或计算机专业学生，我希望院长有控制权，否则可能会有太多东西要学，如果到教授的层面，教学的内容只会增加。

对一些生物专业的学生来说，物理是必修课，我很失望它不是选修课。最重要的科学是数学，其余可以以后再学，有了这个基础很重要，之后你可以让学生根据他们的兴趣学习，更关键的是能够允许学生自己进行实验，给他们选择的权利，并能集中控制项目。这可以保证学生不会花太多时间在必修课上，确保在满足必修课之余可以有更多选择机会，以不同的方式学习。

Brian Coppola

我也觉得平衡很重要，中国传统教育系统可能在早期学习阶段会给学生过重的负担，学生没有时间参与研究。到后来中国教育追赶上来，不得不压缩时间。我认为一开始就应该按照 25% 学术、25% 研究、25% 协作课程，25% 自由安排的比例，培养学生解决事情的能力，并且保持平衡。

四年已经很长，如果给予足够的时间，学生可以做很多事情，那么四年之后会比三年之后更好，三年比两年好，两年比一年好，这样我们可以确信大四学生比大一新生更优秀，重点在于练习和平衡。比如大一学生每周花费

35 小时上课，晚上完成作业，他们根本没有空余时间，这就失衡了，所以我们一定要恢复平衡并实现新的平衡。

苏重豪

我觉得平衡很重要，四年已经足够长去覆盖所有方面。早期的基础训练能让学生具备扎实基础知识，之后发展研究能力，让学生成为批判性思考者，成为复杂问题解决者。我作为老师告诉学生，我很有兴趣教授他们物理概念，帮助他们获得物理基本知识以及如何成为物理学家的基础知识。我也总告诉学生，我的目标是培养他们成为终身学习者，训练学生学习未知事物的过程是非常宝贵的，在这个过程或体验的最终意义上，学生可以在生物医学、生物物理学等领域通过自学成功获得新的知识，即使没有专业学习过生物物理学。所以告诉学生尝试学习的内容以及过程、寻找的方法、解决问题的方法，这才是我们说的终身学习。

Joaquim P. Nassar

我可能略有不同意见，其实在法国没办法实现四年教学。一名学生要成为合格的工程师需要掌握很多技能，既要有国际视野，还要花时间在国外进修，去公司实习或者在实验室做研究。如果说把这些加起来，四年对于我们的工程师培养仍然是完全不够的。

按照现代日常生活中物品的复杂技术，比如当我还是个孩子的时候，想象手机的存在是非常震撼的，电路的发展与我小时候所习得的没有任何关系。我觉得我们只是花更多时间来了解最基本的内容，如果说你不想知道技术背后的物理原理，只想学会怎么使用，那么你可能还是生活在一个魔幻世界里。从国际角度来看，有时候你需要回到当前突破的技术基础上，你不能仅仅依赖建造技术的上层结构，然后从其他人那里购买创意。在某些情况下

我们仍然要连接到基础物理学。

如果用 100 年的尺度来设计生活，并不是说我们年龄相同毕业之后还有 80 年的时间，所以人生被延长了，而是我们来看中世纪的女人，她们在 14 或 15 岁就可以结婚，而现在我们认为不合适。所以事实上，我们整个生命范围被拉长了，所以需要更多的时间去学习，这不一定是连续的一整块学习时间，有些学生到 18 岁会做其它事情，之后再回到校园继续学习，我相信他们最后仍然需要超过 4 年的时间才能掌握到所有有用的知识。

Ramon A. Wyss

我认为这与时间的长短没有太大的关系，我在一定程度上对五年的项目也表示赞同。我们需要关注的是，在既定的学习时间内确保学生能够有足够的进步。修读五年项目的学生并不一定比修读三年项目的学生进步空间大，这主要取决于你的行业领域和学位文凭。三周前，我在青岛见了几个学生，其中有一个学生大概在校学习已经三年了，但在这之前他从未去过青岛，他在青岛花了很长的时间去适应当地的生活。我认为一些日常活动，比如说去本地电影院体验生活，这也会反映在你的学习当中。这种社会互动以及非教学层面的活动是必不可少，十分重要的。

章俊良

对于这个问题，我们得到了一些不同的答案。大体上，我们都认为对于学生来说，获取多方位的知识是很重要的。不管三年、四年还是五年，自身教育体系的设计是很重要的。如果项目学习的时间长，那我们就肯定需要给予学生更多的关注度，引导学生们找到学习的重心，并且一定要去平衡好研究项目和学习项目之间的关系。目前，我们已经分享了许多教育经验，希望能够打造一个非常强的基础。与此同时，我们也希望能掌握高水平研究能力

的培养，这是我们现在正在思考的一个方面。今天还准备了其它的问题，但由于时间的限制，我们先开放问题给台下的参会嘉宾。

听众 A（张蕾）

我想向 Brian Coppola 教授进行提问，您说我们需要马上停止给学生们进行排名的行为，我们应该更多的关注人才培养目标。我想问其他几位教授，你们是否同意这个观点，你们对排名的作用是如何看待的？我们应该怎样打造一个世界级的班级或者世界级的机构呢？

Ramon A. Wyss

这是一个很棒的问题。我比较赞同 Brian Coppola 教授的观点。首先，我认为答案取决于我们试图从排名中得到什么。我认为选择是比较重要的，它无时无刻地都在发生变化，且有时可能是错误的，但排名是一个很好的选择系统，只是我们要确保有 20% 的人可以通过其它方式面试。有时候我们还要面对一个挑战，那就是腐败贿赂的问题。我们需要严谨的对待在校生的排名问题，有一些学生在数学方面表现优异，但却对化学并不感兴趣。我们发现学生在学科选择上会有不同的兴趣点。学生对自己有兴趣的课程抱有热情。兴趣是一个非常强大的驱动力，在此境况下排名就会适得其反，有时会抑制学生们的成长。所以简单的来讲，排名并不一定对学生发展有益处。

Brian Coppola

我之前的观点特指向的是大学层面。目前大多数还是在用高考的方式去给学生进行排名，当然这是个体选择的权利。与我而言，我并不在意这方面的信息。当下，还有 GRE，托福等其它考核手段去全面系统地探讨排名，但

我们知道这与课堂上的学科排名是没有什么关联的。所以给学生进行排名这件事到底是为谁而服务的呢？如果说这个排名系统并不能为学科所用的话，那为什么要存在一个排名系统呢？这件事反而会让学生感到不开心。

Joaquim P. Nassar

我认为 know 比 selection 更合适。给大家分享一个小故事。我曾经在法国综合理工学院工作，当时它是法国工程方面排名第一的学校。1975 年，我们有一场大辩论，议题是在 70 年代，我们是否应该让学校招收女生？那时，高考第一次对女生开放，一个女孩在测试中获得了第一名，所以之后再也没有关于让不让女孩子来读书的辩题了。考试把女性引入到了教育体制中，所以我认为有时候排名能够给我们带来某些公正性和公平性。问题就是当有限的席位存在众多竞争者去争取时，任何的标准都是有争议的。显然，如果我们取消入学成绩考试，大学将会有另外的排名系统出现，有时是根据家长的富裕程度来排名，这种关于不当行为的根本争论我们可以在美国的一些顶尖大学中找到。我们不能够直接依赖一个体系，法国在这方面做了很多尝试，我们将不同的解决方案混合，最终得出最优方案。部分考生通过竞争性成绩考试录取，部分考生录取基于个人教育背景以及个人成就。我们有不同衡量的标准，但即使是这种选择也可能是有偏见的。

王宏伟

目前在中国，学校的排名和名誉是挂钩的。实际上，两者并不对等。排名高并不意味着声誉好。不同的大学有着不同的办学特色。我上大学的时候，我并没有排名，我就是选择了我自己喜欢的学校。这并不意味着北京大学不好，只是因为我喜欢清华大学，所以我就去了清华，我也很开心进入清华学习。同样的事情也发生在上海，上海交大和复旦，我不会说谁是最好的，这

两个大学的侧重面和风格是不一样的。所以，我认为声誉比排名更重要。从生物学的角度来看，世界如此繁荣，如此有趣，正是因为我们有如此多的物种。我们不能对哪个物种最成功进行排名。有时，作为人类，我们说我们是地球上最先进的生命形式。但有时候，如果你仔细想想，我们并不是最成功的物种。地球上最成功的物种应该是微生物。不同的大学有不同的特点和个性，我自己不会做这方面的排名。

章俊良

我认为这个话题我们已经讨论的很充分了。对于排名我们要谨慎使用，我们需要有其它的竞争性方式来对学生进行评估。我想还有时间来回答另外一个简短的问题，请问大家还有没有其它想要提问的？

听众 B（夏伟梁）

想象一百年后，我们有来自不同领域的专家聚集在一起。大家认为今天的讨论对一百年后的世界有什么影响？

Joaquim P. Nassar

首先，我肯定不会到上海来开会。我们应当是在各自的国家通过某种虚拟网络系统来实现会议论坛。比如我在斯德哥尔摩，大家可以通过虚拟网络系统在上海看到我。学校里面也许没有老师，也没有考试。计算机领域的学习完全基于同学们之间的互相学习模式来开展。那时，我认为我们的教育体系也不一定是从小学到高中再到大学的固定模式，我们会有不同的教学方法。我们目前所做的都是重复得机械化事物。我认为学生之间互相学习并互相教学是最好的方法。在未来，我们需要关注于自我学习，没有任何知识能够被

强加到头脑里，这是我们未来的一个新变化。当然我觉得有些东西会来的更快。

王宏伟

我的祖父跟我讲过一个故事。他小时候在私塾学习，如果他不用功读书，私塾先生就会打他手心。在当时，学校的教育是这种形式的。现在的教育已经改变了很多，我们教育系统和教育价值观也在一百年内发生了很大的变化。所以，在一百年后，我们不知道会发生什么。可能由于神经网络技术的发展或者大脑科学研究的发展等，一百年后不再会有学校。时代在变化，但我认为人类的一些价值观还是会存在，我们还是会一代一代地把知识传递下去。

苏重豪

我认为这是一个很难回答的问题。教育体系将会按照社会需求不断地进化，可能未来十到二十年我们会有很多 AI 领域的工作机会。互联网的出现，使一些工作变成可替代的存在。那我们培养学生将会怎样培养呢？可能有一些学科的岗位培训将会消失。随着这些人工智能和数据科学的到来和发展，我们需要培养我们的学生一些新的技能，让他们成为这方面的专家。这是未来十到二十年可能会发生的。但是未来一百年，可能很难去描述，因为我也不知道一百年之前是怎样的。

Brian Coppola

我来换一种方式回答你的问题。我们今天这个研讨会的目的是来回答我们如何去满足培养拔尖人才的需求。未来一百年、两百年可能都是如此，甚

至未来三百年，教育的需求都是去培养拔尖人才。也许程序、工具、流程不一样，我们想要实现的结果不一样，但是我们对于人才培养的需求是一直不会改变的。婴儿出生到成人这个阶段，我们可以进行教育。在过去两百年的时间内，我们发现把高中生转换成专业技术人员需要花十年的时间。科学没有变，我们怎么去实现这一点的方式会发生变化。现在比一百年前发生了很大的变化。在未来，我们会更有创造力、更高效，但是我觉得培养人才这种基本的需求是不会变化的。

Joaquim P. Nassar

预测是困难的，尤其是关于对未来的预测。因为我们的任何观点可能都是错误的。我认为中国发展的原因之一是能够确定进行试验的领域。比如邓小平提出的建设经济特区，对此，西方世界非常感兴趣，政策的实施落地得到他们的一致好评。我认为，致远学院就是这样的一个教育特区，在上海交通大学启动全校范围的实验不现实。我们在某些特殊的大学开设这样的区域进行试点、创新，才是目前教育的趋势。就如同今天上午霍普克罗夫特教授提及的，你不需要很大的资金预算，在学院只需要几个重要的学科，几个重要的课程，几个优秀的教授，就可以开发出新的概念和新的方法，我们对其进行复制，就可以实现成功。可能在我们的学院有一些教授有有趣的想法，如果他们有空间去做实验的话，这个平台就会具备真正的影响力。

Brian Coppola

在座的各位都需要思考这样一个问题。在一百年后，中国对世界的贡献将会比以前更有意义。为什么我喜欢来中国，为什么喜欢和中国互动、向中国学习，是因为中国的历史。我认为你们每天醒来的时候，都需要去思考四十年前的教育举措。40 年前，中国重新定义了高等教育，用一代人的时

间，从1978年开始逐渐地重新完善了教育系统。现今，这一代人仍在世，比如像林教授，至今还在工作岗位上奋斗。我们可以思考一下，在中国的第一届大学生之前，没有二年级、三年级的学长，如果你是中国的第一届大学生，一切都是需要发展的。我在2001年再回到中国的时候，化学系正试图在《美国化学学会杂志》上发表他们的第一篇论文。现在一切都发生了变化，中国效率是非常高的，所做出的努力全世界有目共睹。我认为，在未来中国无疑会成为这个世界的领导者，做出更多的贡献，谢谢。

章俊良

我非常同意王教授的观点。我们有工程师负责工程方面的问题，有科学家负责未来技术的问题。在未来，我们的教育是培养人才的关键。我们需要展望一百年后有关教育者的责任问题，我们要培养学生有更远大的愿景，有创造未来的看法，有全局观、有宏观的跨文化视角，这样他们才能够更好地去培养他们的下一代。在未来一百年，他们会助力下一代完成我们教育者的使命。如果我们不这样做的话，我们将打一场必输的战役。虽然我们今天的讨论还不够充分，但我们的时间所剩无几。我们的小组讨论环节今天到此为止，请专家们回到我们的座位。

四、主题报告（英文原文）

Nurturing Multicultural Effectiveness in Undergraduates: The Why and the How

Jeffrey S. Lehman
Vice Chancellor, New York University Shanghai

It is a pleasure for me to be speaking at this forum, one devoted to a topic about which I feel passionately – cultivating undergraduates' competence.

I will be focusing this morning on one particular dimension of competence: their multicultural effectiveness.

My remarks this morning will elaborate on two points:

- Why we think universities should be concerned about their students' multicultural effectiveness, and
- How a university can successfully nurture such effectiveness.

So why should universities be concerned about their students' multicultural effectiveness?

A couple of years ago, Lynda Gratton and Andrew Scott wrote a bestselling book called, The 100-Year Life: Living and Working in an Age of Longevity (2016).

The motivation for the book was a simple demographic fact. If you look online at the Human Mortality Database, you will find data going back to the early nineteenth century for some countries and the early twentieth century for

many others. The oldest data tables are European countries -- Belgium, England, France, the Netherlands, Norway, and Sweden. And in those countries, people's life expectancies have been steadily increasing by 2.5 to 3 years every decade for almost 2 centuries.

In those countries, the so-called "period estimate" of life expectancy at birth has gone from around 45 years in 1840 to around 85 years in 2000. And in other countries with data from the early 1900's, the pace of improvement has been about the same. And if you use so-called "cohort estimates" instead of period estimates, estimates that take into account how technological and social progress cause death rates at every age to fall over time, it is reasonable to think someone born today into reasonably well-off circumstances is probably going to live to be 100.

Gratton and Scott offer some thoughtful and provocative ideas about how a three-stage life model – education, work, retirement – no longer makes sense, and how people should be planning for 5-stage lives, where the stages come at different times and in different orders for different people. But what if we can't assume our graduates will come back to school in mid-life? In that case we have an ethical duty to ask ourselves how to best prepare our students for a life that will continue for 80 years after they graduate.

Gratton and Scott note that if you are going to live for a long time in a period of accelerating technological change, the specialized skills you develop early on are going to become obsolete at some point. Therefore, they say, "It is ... likely that people will choose to specialize at one stage in their working life and then re-specialize as they shift into other intellectual areas and activities. As a result, formal education will increasingly create opportunities to build foundational analytical abilities and principles. Building these foundations then creates an opportunity to be flexible and innovative and to span disciplines."

Gratton and Scott's emphasis on what they call "foundational analytical

abilities and principles” is consistent with what other writers have emphasized when talking about how students should prepare themselves for a world in which machines will be endowed with more and more powerful forms of artificial intelligence.

On that front, I heartily recommend the book Machine, Platform, Crowd, by Andrew McAfee and Erik Brynjolffson. The book explores the ways that the relationship among technology, economics, and social behavior has shifted over the past ten years, and how it is likely to shift during the next ten years.

The authors do an excellent job of explaining why advances in artificial intelligence will modify our civilization by eliminating the need for people to do routine work. Not only routine physical work. Also routine analytical work. The coming age of smart machines is likely to be noticeably different from the world we inhabit today.

The authors argue that the age of smart machines could be an age of so-called “beneficial AI,” but if people are going to remain productive they will need to be able to do the important, non-routine things that machines will not be able to do. They will need to know how to guide smart machines in socially productive directions, and they will need to be able to interact in skillful, effective, compassionate ways with other human beings, what we call “social skills.” This is as true for computer scientists, for natural scientists, and for mathematicians as it is for historians and poets.

Neither Gratton and Scott, nor McAfee and Brynjolffson, go into much detail about exactly what the foundational skills, the vital social skills are, or how they can be taught. But I have been thinking about this question for a long time, and my own list emphasizes six vital skills:

1. algorithmic thinking,

2. critical analysis,

3. creativity,

4. social perceptiveness,

5. the ability to persuade, and

6. multicultural effectiveness.

At other times I have spoken about the first five skills, but today I want to focus on multicultural effectiveness.

When I was growing up, multicultural effectiveness was certainly not a quality that people would have emphasized. When people of my generation went off to study at a university, we expected to spend our adult lives interacting almost entirely with other people like ourselves. As an American I expected to be with Americans; my Chinese counterparts expected to be with Chinese people; my French counterparts expected to be with French people.

Today's world is very different. All of us are living and working in continuous interaction with people who grew up in different cultures. A couple of years ago, many people said that we were living in an age of globalization, and I even went so far as to describe it as an "age of convergence." Cross-border flows of all kinds were accelerating. Not only crossborder flows of goods and services and capital, but more generally crossborder flows of ideas, of cultural connections, of conversations, of cooperation, of identification, of fellow-feeling, of aspirations for our world.

ETH University in Zurich, Switzerland, has developed a quantitative measure of globalization called the KOF Index, and it measures globalization along economic, social, and political dimensions. From 1970 until 2015, the KOF Index showed dramatic increases in all forms of globalization.

Well, you won't be surprised to know that since 2015, that pattern has paused. According to the KOF Index, after 2015 trade integration and cultural globalization have actually declined, and social globalization has increased only slightly.

And yet, as dramatic as the rise of destructive nationalism has been, and as unlikely as any talk of convergence might sound today, we should not exaggerate the extent of the pullback from globalization. I have no doubt that today's students will be actively working as members of multicultural teams throughout their adult lives.

What I would say is that the slowdown in globalization merely reflects the fact that national borders still matter. Being in China is different from being in South Korea, which is different from being in North Korea, which is different from being in India, which is different from being in Japan.

Different national communities have made different choices about their political and economic systems. Those choices have a profound impact on the tone of everyday life. Just as importantly, those remaining differences also reflect differences in linguistic and cultural systems. Even if the most important values -- such as love and respect, honesty and trust -- are shared universally, different cultural traditions shape the way that people come to express those values and attitudes in daily life. They are taught to engage with the world around them in different ways.

A very interesting psychological literature has documented how children who are born with the same biological wiring develop different cognitive patterns as they grow up in different cultures. They come to perceive things differently, and they come to analyze things differently, because they were taught different answers to the questions, “What matters? What is important?”

About fifteen years ago, interest in this field of research was accelerated by the publication of Richard Nisbett's book, The Geography of Thought. The book is filled with provocative examples, drawn from rigorous psychological experiments. At the risk of oversimplification, these examples give support to the following proposition: people who are raised in Asian cultures tend, in their observations of

the world, to focus more intently on an object's relationship to its context, whereas people who are raised in Western cultures tend to focus more intently on the characteristics of an object that do not change if the object moves from one context to another.

Two years ago another great book was published by a writer who is frequently described as "the great American novelist," a woman named Gish Jen. She was born in the United States, but her parents grew up in China, and that has enabled her to have a profound understanding of cultural differences. In her new book, entitled The Girl at the Baggage Claim, she talks about how western societies nurture a sense of what we call our "self" that is independent, with clear boundaries, whereas eastern societies nurture a sense of what we call our "self" that is interdependent, with fuzzy boundaries.

Perhaps most importantly, Jen argues that in a world where people from east and west are constantly interacting, they need to develop a special quality. She describes this quality as "independence threaded with interdependence," and she names it "ambidependence."

Ambidependent people are endowed with a quality that the poet John Keats named "negative capability" – the ability to hold two inconsistent ideas in their minds without rushing to declare that one is right and one is wrong. They are able to recognize when two people are misunderstanding one another because they are looking at an issue through different cultural lenses, and they are able to help each person to understand the situation with more subtlety, more complexity. They are masters of multicultural effectiveness.

These ambidependent people embrace a cosmopolitan outlook, an outlook that the philosopher Anthony Appiah defines as combining a healthy blend of "universalism" with "respect for difference." People who are cosmopolitan feel that they are part of the same community of spirit as people from different cultures,

they feel that certain basic moral responsibilities are universal. At the same time, they also feel a certain kind of humility, a certain respect for people's ability to make their own choices, so that they don't go around trying to impose the particular features of their own culture on others if they aren't essential to respect for critical universal values.

So how should universities be designed to help their students become ambidependent, cosmopolitan masters of multicultural effectiveness?

There are certainly many, many ways to undertake this task. But it is one that was at the core of how we designed NYU Shanghai, and I believe we have been reasonably successful in our efforts. So please permit me to spend a few minutes talking about our school's approach.

One feature of our school is structural. It has to do with how we compose our student body.

I would note that, historically, neither Chinese universities nor western universities have focused on nurturing cosmopolitan talents. Indeed, almost every university in the world sees itself as promoting one primary national culture. Almost every university in the world draws at least 75% of its students from the nation in which it is situated. It expects so-called international students to learn to fit into the local culture, and it has no expectations at all for how local students engage with foreign students.

In this respect, NYU Shanghai is very unusual. Half our students come from China, and the other half come from more than 80 other countries. In the dormitory, we assign every Chinese student a foreign roommate, and we assign every foreign student a Chinese roommate.

Our faculty also reflects an unusual degree of national diversity and cosmopolitanism. They come from 25 different countries, and they almost all have had the experience of living and working in a country other than the one into which

they were born.

While they are in Shanghai, all students are taking their classes in English, but the foreign students are also expected to learn Chinese. And they do not spend all four years in Shanghai. All our students spend the first two years in Shanghai, and then they leave the country for a year, studying in New York or Abu Dhabi or one of NYU's campuses in 11 other major cities around the world.

So all of our students – whether they are Chinese or not, and no matter what their major may be – spend a significant amount of time living with classmates from other cultures. And all of our students – whether they are Chinese or not, and no matter what their major may be – spend a significant amount of time living and studying in countries other than their own.

This structure gives us an opportunity, and we couple it with a very explicit message that we deliver to our students from the moment they are admitted. We tell them that if they are going to get the full benefit of an NYU Shanghai education, they need to commit themselves to "immersive engagement" with another language, another culture, with the ideals and worldviews of people who grew up in countries other than the one they grew up in.

I think it is very important to recognize that immersive engagement in a second culture is enormously stressful. It is much harder to speak in a second language than in one's native language. It is almost impossible to express oneself as fully, with as much subtlety, with as much cleverness, with as much humor. It is unpleasant to know that you sound dumber to other people than you really are.

Similarly, it is much harder to engage with people whose cultural assumptions are so different from your own. Opportunities for mutual misunderstanding, for unintended insults, for hurt feelings and conflict are everywhere. It is exhausting to feel that one is always the outsider, always the stranger.

And that is why we do not tell students that, while studying at NYU Shanghai,

they must engage only with people from other countries. We do not tell them that they must refuse to interact with people who share their own language and culture.

The definition of “immersive engagement” is not about exclusive engagement with people from other cultures. Rather, it is about creating a daily ebb and flow, back and forth, between the challenge of talking in a second language with people from another culture and the relaxation of being with one’s compatriots. This ebb and flow calls for a minimum of two hours each day living beyond one’s most natural comfort zone, actively engaging with foreigners. Two hours is the threshold that separates immersive engagement from life in a domestic bubble.

The good news is that, if one fully commits to this experience, if one goes “all in,” one discovers that the two hours each day become less stressful in the second month, and much less stressful in the third month. One’s linguistic and cultural competence will grow much more rapidly than most people imagine possible.

When I think about NYU Shanghai’s commitment to nurturing multicultural effectiveness, I must say I think that our commitment goes beyond structure. It is infused throughout our curriculum.

Long before they are allowed to select a major, every student at NYU Shanghai must take a course called Global Perspectives on Society (“GPS”) during the first semester of their freshman year. Students in GPS study global intellectual history. They read and discuss the ideas of great thinkers from around the world, considering topics such as human nature, good and evil, liberty and equality, labor and capital, race, gender, and sovereignty.

During NYU Shanghai’s first three years of existence, I taught GPS – the very first year together Professor Paul Romer, last year’s Nobel Prize winner in economics. We used a style of teaching, the Socratic Method, to become better at close reading, questioning, and respectful challenging. They discovered that the answers to the questions we were studying could not be memorized from the

great thinkers we were reading, since, for example, Mencius and Xunzi disagreed with each other, Mill and Rousseau disagreed with each other, Kant and Bentham disagreed with each other. And they also discovered that they could not simply try to learn the answers from Professor Romer and me, because in every class we would disagree with and challenge each other.

During the first semester of second year, every student, no matter what kind of major they will end up pursuing, must take a course called Perspectives on the Humanities. Students in POH study art and literature and music. They read and discuss great humanists from around the world, considering the ways in which similar themes are explored within different cultural traditions.

Courses such as these naturally promote cosmopolitanism. They broaden our students' intellectual perspectives, and they also broaden their base of topics that they can discuss intelligently with one another across cultural boundaries.

More generally still, our curriculum reflects a philosophy of liberal education, whereby all students are required to become deep within one academic major area while also becoming broad through the satisfaction of distribution requirements in the humanities, social sciences, and natural sciences. This philosophy of liberal education certainly contributes to multicultural effectiveness. But I must note here that, even more importantly, it is enormously important for another of the six skills I mentioned earlier: creativity. The academic research on this point is crystal clear: a liberal education nurtures more creative mathematicians, more creative computer scientists, and more creative finance professionals than a more narrow, specialized education.

And our pedagogy reflects a philosophy of active learning, whereby all students are expected to participate actively in class, to become comfortable suggesting ideas for group discussion that might not withstand serious scrutiny, to listen with critical sympathy and critical skepticism, to express disagreement

intellectually and with civility, and to work as active members of multicultural groups.

I do not believe that a university needs to look like NYU Shanghai in order to help their students improve their multicultural effectiveness. Any university, regardless of its structure, can give its students the clear message that their university years will be a time of change. Whereas in high school, education was probably teacher-centered, in which students' mission was to master the messages they received from their teachers, their university experience will be learning centered, combining mastery of a major with broad exposure to a more general education.

And any university can require its students to spend a year, or at least a semester, studying overseas. As long as students do so with a spirit of immersive engagement, as long as they do not attempt to live inside a bubble with their compatriots, they can have the kind of life-changing experience with multicultural effectiveness that I enjoyed during my year with the Sweet Briar College Junior Year in France, more than 40 years ago.

As I said at the outset, I believe that universities have an ethical duty to do more than prepare students for jobs during the year after graduation, or even during the first ten years after graduation. We need to be preparing them for hundred-year lives, and cultivating their international competence is an indispensable part of that preparation.

Education for the Information Age

John E. Hopcroft
Turing Award Winner, Foreign Member of Chinese Academy of Sciences, Professor of Cornell University

It's a pleasure for me to be here today, have an opportunity to talk about education for the Information age. I thought I would start by just telling you that we've undergone a number of revolutions in the evolution of humanity. We're undergoing one now, where the impact will be as great as that of the agricultural or the industrial revolution. So I would put this slide up to show you that these revolutions have been coming at a rate of 10 times faster. And in the earlier ones, when humans first evolved, they were hunter-gatherers. And when the agricultural revolution came along, it allowed communities to form, and the actual population to increase. And so I'm going to talk a little bit about education.

Prior to the industrial revolution, you really didn't need a formal education. If you worked on a farm you simply learned from your parents. But after the industrial revolution, it was important to have a high school or a college education. After the information revolution, you're gonna need a much stronger education. One of the things I want to talk about is the resources for first-rate nations. After the industrial revolution, materials and energy were the denominators of powerful countries. But after the information revolution, it will be talent. And China needs

to focus on developing world-class education to provide the talent necessary to become a world power.

Basic talent is uniformly distributed over the world. And so China has 20% of the world's basic talent; but unfortunately, educational opportunity is not. And for China to become the world's power, it needs to create a world class educational opportunity for all of its citizens. So I'm gonna talk a little bit about what it would take to bring education up to world standards. And I'm going to talk primarily about undergraduate education. One of the first things, one does not need to upgrade an entire university. If you simply select five important departments and focus on improving the five selected departments, you'll have a tremendous impact. And one does not need to upgrade an entire department to upgrade the department, just select the 10 most important courses.

And if a faculty member teaches two courses a year, one each semester, it means you only need five truly outstanding faculty. Now economists are gonna tell you, you get what you measure. So you have to make sure that you reward the right items, and their teaching excellence, and professional reputation is viewed by international experts. You don't want to count the amount of research money. You don't want to count the number of publications, because if you do, that's what you're going to get. Now there's going to have to be a transition from old to new. And I suggest creating a center for new faculties. While for the new faculty, you pay a competitive salary, you provide PhD lines for junior faculty. That's the most important thing for their development. Have them teach one course a semester, ignore research funding, and the number of papers published for promotion and focus on teaching excellence and professional reputation as viewed by international experts.

Also, although I focus in computer science where you provide a very technical education, there's a need for a broad education. Most of the students will not be

researchers, so they're going to work for a company. The project they're gonna work on is so large, an individual doesn't do it, but you got to be a member of a group. So teaching a student how to work in a large group is an important aspect of education.

And some may eventually move to government leadership positions. So it's important that they have an education, which is much more than that in the technical area, which gets them a good initial job. So they should be exposed to either history, literature, art, sociology, philosophy, music, things of that kind. Now, I thought I would very quickly talk a little bit about issues in providing the world-class education, because people who study what makes a good faculty member, say the most important thing is whether he or she cares about the success of their students.

So I just want to give you a story. It's called chicken soup for a child's soul. And this there was a college professor in sociology who took his class into the Baltimore slums to get case histories of 200 young boys; and they were asked to write an evaluation of each boy's future. And in every case the students wrote, he hasn't got a chance. 25 years later, another sociology professor came across the earlier study. And he had his students follow up on the project to see what had happened to these boys. And just because the issue of time, I'm just going to quickly skip part of this. But what they discover is that almost all of them had achieved extraordinary success as lawyers, doctors and businessmen.

So the sociology professor was astonished and decided to pursue the matter further. And he asked each of these former students about what led to their success. Each one of them said there was a teacher. So the teacher was still alive and he went and looked up the teacher and asked, what magic formula did you use to pull these boys out of slums? And the teacher simply said, it's really simple, I love those boys. This is just to illustrate something that is really critical for a fact to them, that

they care about the success of their students.

One of the things I’m gonna talk about how to evaluate a faculty member. I think here in China, there are some things you’ve got to start with first. But I have when I was at Cornell, I developed a way of measuring whether someone really cared about the success of their students. So it can be done. I’m gonna actually skip the structure of my talk, because I want to stay on time. And there’s a number of issues that I’d like to bring up. If a faculty member, if you’re training them to be a good teacher, you want them to engage the students, not to sit at a desk, and look at PowerPoint slides, stand in front of the class and lecture, and with the tone of your voice, and with your hand motions, and so forth, actually engage the students, talk to them and watch the faces of the students and see if they’re actually listening to you. And if not, figure out how to engage them. And we want the faculty to focus on intellectual concepts. Before you start your lecture, you want to know what are the essential ideas that you want students to remember from that lecture. Our previous lecture here was an outstanding one, because I picked up, I think, what his intellectual ideas are, and he got them across very well. Question is, are the details important? Know what you’re trying to achieve in your lecture and get that across.

So mathematical proofs, instead of a precise mathematical statement, it might be better to simply say intuitively what the theorem means. And instead of spending time giving a detailed, precise proof, why not outline the intellectual arguments which are needed to prove the theorem? And just do it enough details so that when the students want a proof, they can take their notes and put the proof together. Go over your lecture. Don’t give the same lecture each year. Every time I give a course, the course is different, because I try to remember where students had trouble the previous year and how I can present that material better.

I’m going pretty quick because there are more important things at the end of the talk. I don’t want to lose time. So don’t just follow someone’s class outline.

A slight material you find interesting, cover that. It turns out the actual material covered is not that important. The student learns something more than the material you cover. But when you assign homework, make sure the homework is geared to the important ideas in the lecture, that they're good examples to illustrate important points. And use simple exercises, which will get ideas across. One of the things I do is to encourage students to help one another.

If you can't do a homework exercise, go and talk to another student and ask how to do it. And this is important; but to bring out that education is much more than what you learn in class. When I was dean of Engineering at Cornell University, it turns out that the CEOs of 10 of the Fortune 500 companies had graduated from Cornell engineering. So I visited each of them and asked them what they had learned at Cornell that helped make them so successful. Not one of them mention anything they have learned in class.

So an education is a lot more than what is taught in class. And something that's important here is the students are spending so much time in their courses and in doing homework that they're not engaged in many of the other activities which are an important part of the education. You want to communicate clearly, speak slowly, write what's important on the board. What I think, I hope is that somebody here can make these slides available to anybody that wants them, so that I can just move a little faster and get to more and more material.

I wanna talk a little bit about if the mission of the university is to produce the next generation of talent, why are we interested in faculty doing research. Part of the reason for that is a teaching career is 40 years; and we don't want faculty members towards the end of their career teaching material which is 40 years old. Engaging in basic research is likely to keep faculty members teaching an up to date course. And it helps faculty focus on intellectual ideas. But I'm gonna make the point: It's not the research that they do that we're really interested in.

So I should probably talk about the difference between applied research and basic research. It has nothing to do with how fundamental things are. Applied research is done because there's a national need or a company has a need. And in the United States, it's done either in a company or in a national laboratory. And it's got be focused on and done in a timely manner, etc. But basic research, the definition is it's because you're curious about it. So the difference between the applied and basic is why you're doing it.

If you're curious about something, we do that kind of research in universities because we're not interested in the actual research. But we're interested in the faculty member doing something that he's interested in. And some go in that direction and others that direction. They go in all kinds of different directions. Most of it has no research value later on. But occasionally one of them goes in some direction that creates a whole new industry and billions of jobs. And it turns out that even though we've never looked at what was the result of the research, it was probably one of the best investments the US made by doing basic research in a university. And when I got my first research grant from NSF, they did not require me to do the research that was in the grant, because that's not why they funded me. They funded me to produce the next generation of talent. And if some other ideas came along which I thought were better, that was fine. I didn't have to tell.

They didn't even ask for a final report from me. The university had to send them a financial report as how the money was spent. But I didn't have to report on what research I had done. So now it maybe a little bit later on. I'll talk maybe in China we have to have a slightly different policy. Teaching things like ethics. Very important. And every situation you make with the student has to be in the best interest of the student. For example, Cornell university, if there's a faculty member doing a start-up, they will not allow that faculty member to hire a student to work in that start-up. Because that student, if there's a decision, he can either do A or

B and doing A is in the best interest of the company, and B is in the best interest of the student. The faculty member might suggest A rather than B. That's highly unethical.

So I want to talk about evaluating a teacher. What you want to look at is, does the teacher have enthusiasm for the material? Does he engage students? Does he communicate clearly? Does he respond to students' questions? Effective use of blackboard or PowerPoint? In other words, you want to actually sit in on a lecture and see how well the faculty member is doing. If you're evaluating a faculty candidate, remember that candidate's career is gonna be 40 years. So don't focus on the specific research plan that they have when you're hiring. What you want that faculty to remain active and not teach 30-year-old material. So questions that I would ask, look at in hiring a new faculty member, are they curious person, are they interested in exploring new directions? Do they have a broad range of interests outside of research? And this is what you really want to know is this faculty member going to stay active over their entire career. For those of you helping faculty to improve teaching, there are a number of things you can do. You can improve their teaching style. You can also help them with content. You can sit on a lecture and see how well they're doing. But it's pretty hard. Unless you've hired somebody who really cares about the success of students, there's not a tremendous amount you can do. But the evaluation of teaching, sometimes a side effect is more important than what you're doing. When a university is evaluating teaching, it sends a message that teaching is important. And that message may be more important than the evaluation process. Here in China, if university presidents, deans, and department chairs know that their reputation will depend on the quality of teaching, and then teaching will become valuable and become outstanding.

Because remember, university presidents have a 5-year term and they're looking for a better job. If you're measuring the amount of research money, how

they increase the research money at the university, or how they increase the number of publications, that's what you're going to get. And so you want to make sure that their evaluation for their next job is how much they improve undergraduate teaching. And also unless you improve the environment and reward structure for teaching, you're not going to improve it. So what I want to mention is that university education in China is changing. It turns out that this is very important for China's stability. Your Premiere, that was one of the first things he told me. He said his highest priority with stability of the country. To do that, he had to increase the standard of living faster than people's expectations went out.

And to do that, he had to increase the gross national product. And to do that, he had to provide the talent that companies needed to continue to expand. And that meant he had to increase the quality of undergraduate university education. And I think university presidents are getting that message now and you're gonna see a change very quickly in China. So what changes are necessary? And I think that primarily it's improving the environment for junior faculty; because teaching is not going to improve until the environment is improved. And what you want is junior faculty doing what they want to do, what they find exciting, reduce the teaching load to one course each term, assign junior faculty a PhD slot. Universities are allocated a certain number of PhD slots, but in many universities, they have been divided up among the senior faculties.

But the most important thing for junior faculty development is to have a high quality PhD student. And that means you're gonna have to pull some of those PhD slots back and give them to junior faculty, and change their promotion so to be on the quality of teaching and professional reputation. The Chinese environment is different than the US and so you gonna have to develop a strategy that is consistent with your environment. And it may be that the university here may have two missions in the short term. One is to produce the next generation of talent, but it

may also be that you have to help China with applied research, because there are not enough talented scientists and engineers for companies to hire what they need.

But what I hope is this last line is what's important is make sure that the applied research mission does not interfere with the environment for teaching. Because what is most important is the development of the next generation of talent. So the nation will have the talent to do the applied research in companies or government laboratories. So environment threat for excellence teaching is a reward structure for good teaching, remove pressure for research funding and number of papers. Tell them you're not going to look at that. And help develop a climate for curriculum development to change a course.

Okay, the mission of the university, I believe, is to educate the next generation of talent and broaden their lives. And the world is changing and issues are arising. And technical education is important. But broader skills are also needed. If you're gonna have the leadership, which is going to help you in this new generation. But one of the things why probably I didn't realize quite the format of this talk, so the slides not gonna make sense. Because I say don't just lecture to your students but engage them. And that's what we should do now but I don't think we have the time for me to engage you and answer questions at this point.

So I'm simply gonna say thank you for giving me this opportunity to talk to you about education.

Cultivating International Competence of Students: A French View

Joaquim P. Nassar
Head of Strategy, Expertise and Management of International Cooperation Programs Department, Ministry of Higher Education, Research and Innovation, France

First, I’d like to thank Shanghai Jiao Tong University and Zhiyuan College for inviting me to speak today. My talk will be about cultivating international competence of students. I will give a French point of view for this question.

First, I will shortly introduce you the French higher education system, which may be a challenge. There was a famous saying from Greenspan, who says that if you understood what they say, it means that they didn’t explain it well. This is a bit what you could say about the French educational system. Then I will mention what the government invests to develop international awareness of students in France, especially through inbound and outbound mobility. And we try to dedicate about half of my total case study, which is what I have to achieve here in Shanghai Jiao Tong University, trying to experiment the French system in the Chinese university, and what kind of challenge it was.

First, a few figures about the French higher education system. The total number of undergraduate students in the French higher education is 2.6 million. To be compared with, about 9 million students every year will take the “Gaokao”

in China. They are not the same orders of magnitude. It's a growing number for demographic reasons and also because there is a policy to promote the access of a higher proportion of the students in France to higher education. Regarding there was written, there is a category seem in the 303 billion euros is spent in public education per year, but it's 230 billion RMB I remember, but here 23 billion and I have to apologize for this. And it represents about 1.5% of GDP which is probably not enough, I think. If we evaluate how much the government spends on their students, because in France higher education is mostly publicly funded, we are in the range of 11,000 euros which is about 88,000 yuan. And 88,000 is a lucky number in China.

As for undergraduate education, which is the focus of today's session, it's not really a European concept, because in the US and China, you have a very important milestone after four years when you graduate as a bachelor. And then you may or may not decide to start graduate studies, which are usually directed towards research and towards PhD. In Europe, it's not the same milestone. The so-called bachelor or master, doctoral system, which you get in France bit by bit, is a European system and there is a milestone after three years. So bachelor in Europe is three years; master's up to five years and then PhD can be three or four years. I would say that the recent situation for professional education and especially engineering education in Europe is rather the master level than the bachelor level. And so this is the difference that we as simply have to keep in mind.

We have then the French system. It is a bit explicit, mass education is the duty of universities. So about 1.5 million students are enrolled to attend universities, and you will see that it looks complicated. There are 73 publicly financed universities all over our territories, covering all disciplines, providing a broad range of degrees, having also research duty and you have a lot 1500 thousand academic staff in these universities. I would say to make it simple that, in German universities there

is mass higher education. And there is so-called elite higher education which is modern duty of what we call in France, grandes ecoles. “grandes” means large but in fact they are small and you could consider it as French paradox. It’s a bit of a specific French feature inherited from history. This kind of school studying center in parallel with the university system since about the 18th century. And entering them is the right way after high school, after the degree that we call in France, baccalaureate, or after what we could trip out our classes, which are very competitive systems. Typically, these preparatory classes have been taken by about 80,000 students and they cover especially fields like engineering. With more than 200 schools teaching relevant courses according to calculation, you see that these schools have about 700 typical students in small institutions. Also, management studies are mostly the responsibility of this grandes ecoles. Actually, details and so on are the same. So it’s a bit of an explicit system.

We will talk today about international education. We need to make sure that we kind of reunite the systems, because you know that in most western countries, even the ones considered that most successful, the separation between the elites and the mass is a threat. And in many western countries, you have had a crisis of populist and nationalist movements where the mass considers internationalization, considers privilegentsia as threats. On one side, the elite that is very globalized, that ever has international experience, that uses internationalization as an opportunity, getting separated from the mass that is just afraid of privilegentsia. And clearly this is something that we have to take into account in the education policy. To unite different systems, successive French governments have encouraged clusters, bringing together the universities. So the ones with mass education, the grandes ecoles, the research centers and also company research centers are going to integrate higher education research innovation and to have bridges between the mass and elite education when mergers are encouraged. And this moment has also

been motivated by international business.

The previous map you have seen was quite complicated and quite difficult to explain in the international environment. The core is to have a reduced number of clusters with an international disability. So we have two such types of cluster styles, what we call IDEX (Initiatived' Excellence), which are meant to be comprehensive; and small, specialized, more thematic clusters which we call I-SITE, used to develop excellence in one special field. So I was mentioning the goal of the French government to develop international awareness, not only among the elites, but also among the mass.

I was totally in agreement with the talk from professor Ramon. It's very important that the students are already doing their years of studies, experience multicultural environment, experience international environment at home and through mobility. And it's important from an economic point of view, especially in Europe; if you want to work with integrated European companies, you have to know enough as a Frenchman how the German would think, how the British will think when the British is being in a complicated progress. They will take Brexit for instance. And you still have to experience at home what it is to work with Chinese fellows, with great Brazilian fellows and so on. You have to learn at home and you have to learn through mobility. And it's also important to understand markets. If you want to understand the taste of the consumers, if you want to develop products that can be successful worldwide, you need to have an understanding of how the rest of the world thinks.

France is kind of a country of economic mobility. About 300,000 foreign students studying in France, which makes France the fourth country worldwide in terms of incoming mobility, the first non-English speaking country in terms of incoming mobility. Here I won't go into the details, and after the release the top of countries of foreign students' mobility, China was then about two and is now about

three and we would strongly encourage more Chinese students to come and study in France, especially because we organize surveys about the satisfaction of students who come to study in France. And the overwhelming majority of foreign students has a very positive experience of their studies in France, well...and still go to the higher scale in a student incoming mobility. The government has recently launched a corrective strategy, which is called Choose France, with a clear objective of increasing the number of international students in France to 500 thousand within 2027. With many types of actions, it’s still bothering them not to get a visa. So there is a corrective action to make just a visa application for students. Similarly, we are aware that French language is challenging for many nationalities. So funding would be ready to have more programs to help foreigners learn French in their daily life.

At the same time, it was a bit hard to understand France to encourage more programs in English, which is not the typical French culture and way of thinking. But now it’s pretty simple. We are also being encouraged to apply labels for the quality of the way they post and welcome foreign students. This has a quest. So tuition fees which are traditionally very low in France will be adjusted to contribute to defending of these actions. I won’t go into the details of the figure that here the average figures were outbound mobility. France is a country of outbound student mobility, the sixth country worldwide, China is number one. If you look at the countries where the French students go, there is a big country which is not in the top 25, and it’s China. And for any degree of it. And clearly it does make sense. And given the importance of China in the world and China as a partner of France, we want to encourage more students to take the step of going to China, not only for six months as exchange students but also complete degrees. Chinese outbound mobility is mostly in Europe, especially. It has been like this for about ten years because of the famous ERASMUS+ program. And we’re not going to mention

details.

What comes next is to upgrade the French mobility, a new initiative has been launched this year, strongly pushed at the European level by pressing them to come back home, which will be in quite a few universities. And it's interesting to just say this initiative will be carried out in Europe universities between the networks of a small number of universities, typically from four to six institutions, making it easier for students to travel from one university to another, and to spend one semester in the university and another semester in not-their-own university. Typically, this new sector will be also made available to visiting students from other areas of the world. I was mentioning that the French education, the French overseas education will be also a more explicitly part of the government's strategy. French education is presented in many areas of the world as you see on this map. China is clearly one of the priority destinations for the local implementation of French education.

And during the rest of my talk, I will focus on one case study, which was what my task was about, which is implementing here in Shanghai, with Shanghai Jiao Tong University, the experiment of engineering education. So just to mention shortly in France, engineer and engineer officer is a regulated title. There is a body who gives you an accreditation to the very engineering data. It's called the CTI which comes from an international engineer. Publisher is very nice, which are available in English on their websites. And CTI has in fact the definition of what should be a good engineer. And that's really so engineering can be defined as posing and answering a complex question in an effective and innovative way, in the fields of creation, design, production and implementation, within a competitive environment and with a focus on products, systems or services, and possibly their financing and sale. As such, engineers should have a good understanding of technical, economic, social and human issues, based upon a solid scientific background. So you see that an engineer is, the definition of the engineer is by far

broader than that of a technical engineer.

I will try to be fast so that we can go to essentials. An engineer is supposed to have quite a wide array of skills, which is here on the screen because you don't have these abilities indeed. You should be ready for the very long professional life. But at the same time, you should be engaged in different research activities. Research and innovation have to be part of the awareness of engineers. Please look at the next picture, and clearly communication skills and international skills, are considered to be an inherent part of the skills of an engineer. Of course, it takes time or this may take a full life; but at least it is considered in France that an engineer takes five years. But typically to ensure the long canopy that means you spend quite a lot of time on the four types of skills, including the knowledge of mathematics, of physics, of computer science, of chemistry. And this is typically achieved in the first 2~3 years of intense training in the system I mentioned here. Essentially you decide at the quite late stage where we are specialized. At the beginning, if you want to be an engineer, whatever you feel, you start with the same training in math as someone who wants to become a mathematician. The same training in physics as someone who wants to become a physicist. And there is a quotation, “the education I received during these preparatory years played an essential role in my following scientific career. Without this education in mathematics and physics, delivered by remarkable teachers, I could never have attained the level I achieved.” It's a quotation by Claude Cohen-Tannoudi which is Nobel Prize in physics 1997. As for the education system in France. Here are a number of living scientists who went through it to find their areas of research, because a lot of French leaders are from the countries of France. So the number of political leaders. So we can move now down to politics.

After spending time in the foundations to have practical skills that you need immediately comes your career. Professionalization, which happens later

than typically in Chinese universities, is the close collaboration with companies through environment of company experience in the teaching, through internships in companies that right after the curriculum, and also through direct...uh...so you have some engineering education. The center in China with contribution from the experiment industry of students spending internships in universities. So experiments in the French education in China happens in so-called Sino-French Institutes of Engineering.

After China has acknowledged that the Chinese students who were sent to France received good training, the Chinese government has encouraged engineering education here in China through Sino-French institutes. And these institutes become a part of the Chinese development strategy to reform its higher education by experimenting with successful foreign models within Chinese universities. So before the Shanghai Jiao Tong-Paris Elite Institute was founded, there were a number of previous examples, some in Beijing, and some institutes dedicated to aeronautics in Tianjin and some dedicated to nuclear engineering in Zhuhai. And the partnership was forged between these cities. So the institute that I have been working for started to cooperate with Shanghai Jiao Tong-Paris Tech Elite Institute in 2012.

The collaboration between Shanghai Jiao Tong and four French "Grandes Ecoles". But such collaboration could be unique. With the mission of educating high-quality talents, our joint projects aim to cultivate industrial leaders and innovators out of Chinese and international students, those with a broader scientific background, and those who have the ability to evolve in a multicultural business environment and one specialty field. Typically we have three of them, ICT, Mechanical Engineering and Energy and Power Engineering. It's also an explicit mission of such institutes to develop Sino-French research and promote innovation. Also because I don't want to go into the details, we just skip the details so as to

read and get in the proceedings.

I just want to reflect on what challenges we face when implementing the French-style education here in Shanghai Jiao Tong University. First, let's be realistic. Unlike Chinese model, the French model is rarely known in China. So first, there is the issue of attractiveness of such a model for the Chinese students, for their families, we have to work on it. The Chinese students, the Chinese families, if they know about the French system, things will become easier. So it's about to explain the value of the curriculum that differs markedly from the mainstream, especially, of course, at the time of joining job market, but by far, at least not yet maybe. You have to explain to students the value of the study effort that you require from them, especially for instance, what is the value of learning French language. They purely understand the value of learning English, but French, you have to work on it. We discover our curriculum is integrating bachelor and master curriculum, and the good news was the students discovered that after getting their bachelor degree from this, they would get a plenty of opportunities when they want. So it's good news for the students but it's indeed a challenge for our institutes because they are finishing their studies with us. That seems good news that after four years, I have been familiar with the system. Clearly, when you want to implement foreign model in China, what matters is human resource and how sustainable you can make it. Typically, you want to ensure long-term interests and involvement of the foreign faculty including local residents and visiting professors. Professors are usually quite excited to come to teach in Shanghai for one, two or three times, but what about come here to five years, ten years. This is a bit more of a challenge. We have a share of French-speaking faculty which is a rare resource in China. So how we can recruit high-level French-speaking Chinese faculty or how can your train these people. And it was so mentioned by some of them, can the Chinese system deliver benefits to teachers and professors who mainly focus on

teaching.

This is really an important debate in China. And when really dedicated to teaching, you have not so much time for research production and publication. There are more difficulties in China that teachers will have to overcome. We deliver the French engineering data based a SJTU master degree. And I think you all know that the objectives of the two systems are, in fact, different. When you are about to complete a master degree at SJTU, typically you have few courses because you're supervised by professors who expect you to be focused on laboratory work and publication during two years', three years' time. In the French educational system, because we spend most of the time in the first year developing fundamental skills and the specialization comes later. So it's at the late stage of the curricula that students prepare for their first job, spend time in companies, have management courses, have final internship. They also all go to France, at least 6 months mobility. So clearly, they have less time available for laboratory work. And it's a constant challenge to explain to the professors who supervise them that they spend less and less but they can bring different outcomes, because what they learn in courses is not a waste of time. So I want to mention this because I think it's about how we could achieve from we do it practically in China. It looks like a long list of challenges. But we were very happy just two months ago that we have discussed results of the employment of our first graduates on the Chinese job markets. And it was a big success. So all the set of skills which the students acquired through hard work and sure, an excellent evaluation system helped them seize job opportunities. That's our best reward. Here is a picture of the graduation ceremony we had just two months ago. Thank you for your attention.

Sharing Our Experience in Singapore

Chong-Haur Sow

Head, Department of Physics, National University of Singapore

Good morning, first of all, I would like to thank Prof. Zhang for the invitation to come to Shanghai Jiao Tong to share with you some of the ideas and experience that we have. I'm not in the positions to influence national policies. So what I'm gonna do is that for my part of the talk, I'm going to focus on giving you some specific examples of some of things we're trying in Singapore. Hopefully that some of these examples could be useful and I want to hear your feedback about how you think we can try to go together and make it more interesting.

So on the international forum on cultivation towards talented undergraduates. I'm gonna share with you a few examples of some of the experience and things that we try to do in Singapore. Good or bad, we are still trying to work on it there. So the list of the items I want to cover includes things like science research projects, a science demonstration lab, then young educators in science programs, UROPS—undergraduate research opportunity programs in science and final year program. And we have a special program in science that I would spend time to elaborate a little bit more about; tell you how we try to group talented students together to formulate very interesting synergy in education for youths. And I'm going to also spend some time talking about some of the experience that we have in sending

students for competitions and exchanges.

And then our professors sometime they try out interesting way to teach, aiming, of course, to see whether we can have more impact through teaching towards a student study. So let's start with the first topic, science research projects. For high school students in Singapore, you know that the country is so small and resources are limited for we have a lot of people. So the Minister of Education in Singapore spend a lot of time trying to teach the young kids and give them opportunity to grow early. So this science research project is that every year, the middle school education in Singapore will do some selection tests to find about 10,

sorry, find about 100 very very talented high school students. And what they would do is that they will spend time in institutes of higher learning to carry out research projects and then try to do interesting investigation. So the idea is we always have students coming in with a mentor. The job of the mentor is providing opportunities and resources in the university to the students if they spend half-a-year, one year, and some of those students may spend an entire year or two years just to finish the job of the project. The other is giving them the exposure to what's life about as a researcher in the university, in the sense that hopefully they will think about going this particular path when they pursue their journey in the next phase of the education path. So it is quite rewarding to educate these students in university. So typically you have a group of students and then the students will follow a senior student. So it is beneficial for your undergraduate students because he or she will get to guide the students in this particular manner.

So we do have a bit of interesting results. So some students are very very dedicated and if you give them high-risk projects, you may not though; but it doesn't matter because you can find out something interesting. So for example, we always offer a post for graduate students who back then to serve as a mentor. So they actually can see a scientist in actions how they go about trying to figure out,

understanding very complex problems and learn about multifaceted approaches to solve problems. Okay, some of these students with their very interesting publications get to tell the world about what they have discovered. So here are many examples of students doing well in terms of research and publication. Many of them do pursue, particularly pursue education in a higher level and their publications may be included in academic journals; so they are very proud of this.

The next topic I’m gonna tell you about a science demonstration lab and young educators in science programs. So in National University of Singapore, we set up this lab and call it science demonstration lab. The purpose of this is to have a lab that we can use it to cultivate students’ interest in science and tell them they’re learning physics in particular. You see I’m following, this is my department. It is not super super hard, this is the common misconception. So the idea is now having this particular platform to showcase science to them. In the year 2002 and then in 2008, we go to the faculty level. So our wish, for example, you see pictures of students coming into the lab, finding that the scientific phenomenon is very exciting to them. And many of them have been intrigued so as to think hard and figure out the answers on their own about the phenomenon they have just seen.

This lab is also useful for teachers. So Minister of Education typically encourages teachers to come and visit the lab. The idea is to share resources, share ideas, share experiences about how we can get things done. And then for the professors, this is very useful. So for example in the University of Singapore, one of our goals is to teach...

He or she may not just go with a laptop. He walks to the classroom with collections of toys. Look at the picture here. So we have this we call a mobile science lab. The professors push this for the LTs. And when there are discussions about, let’s say electromagnetic shooting, then there’s a very illustrative graph. So this lab has received many visitors. Over the years we can receive about 35

thousand students in this place. I must remind you this figure is actually small. Every time you can entertain about 20 to 30 students. So accumulatively 35,000 students, can you imagine how many times you have to tell the same joke?

Okay. So the next topic is this platform of science demonstration that has been used for undergraduate students. So we use this as a platform to engage our undergraduate students. First, you know the science, then you make it to understand the science. When you have to explain the science, this is a very very challenging thing, and we really understand the concepts behind. Next, we explain the science in a simple language. So as a result, as mentioned, teaching is the highest form of understanding. So we engage our undergraduate students in this program known as young educators in science programs. It's over here. So the idea is we bring our undergraduate students to become ambassadors of science. You see over here that the students were explaining the science to the public who come to the science center and through the explanations of the science, it becomes even more in-depth understanding about the concept they discussed.

So this platform of young educators in science programs is to engage our undergraduate students to contribute as a demonstrator in promoting science to the general public. So these students are very creative. Sometimes they do come with their own ideas of what they want to do with the demonstration or to create the demonstration study case. Well, we can encourage students interested in education and science to be constantly engaged, and cultivate a balance between these young members to be involved. The good thing is the Ministry of Education in Singapore is very very open-ended, and in terms of idea, after one completion, we give our student a certificate. Okay, so let me show you a picture. So now you see that these are students, undergraduate students who become ambassadors and they explain the scientific concepts to the younger kids who come and visit the university. Or if they don't want this, you see we're gonna have another center to engage them.

Sometimes we even use the ideas of researching great instrumentations to carry out this particular process.

Sometimes we have a DIY workshop whereby we have toys and tools, whereby we get the students to make and create. And then the students can bring the toys back with them at the end of the particular sessions. So here is the pictures of our young educators in science programs students discussing things at a science center. So you see the younger students are working on a project. Okay, and then here sometimes we make our science demonstrations to the shopping center. Shopping center usually have open space. We can set up apparatus and then teach the kids who come to visit.

The next topic I want to discuss is this idea of the “UROPS”, undergraduate research opportunities in science programs and then the final-year project. It’s nationally used in Singapore on one typical model for every four years...and in year four, it is compulsory that every student must carry out one year-long final-year project, and the research project can be entirely computational or experimental. But some students show very strong interest in pursuing the life of our research. Students have research ideas early on, so he or she does not need to wait until the fourth year to carry out research activities as young as a year-two or year-three student, they can knock on the door and tell the professor, say “Can I go with you for a semester-long or a year-long research project and then learn about cultures of the research environment.” So here’s an idea.

Okay, we offer unique opportunities for students to work with our faculty members to experience challenges in figuring out things. One of the important means for attitude-foster mentoring relationship comes from here. So the environment and culture here attract them to come to the lab. It allows them to engage actively in research discussions with the research group, and then complimentary custom exercises are here. This is quite typically done in the year

two or year three. Get they come in and they can try whatever project they want. The experience's aim is of course to prepare them for the future of a more engaged environment here.

Then the final-year project is compulsory for everyone. As mentioned, they have to do this and this is usually in their last year of their academic study, academic journey, the program. So here are some of the pictures of the students who engage in this program and pursue of studies of the problem and figure out what things are all about, and then it can be a lab base, and also the theoretical settings. So we do have students who have done very well in this particular aspect. So they're spending time in their research projects, and then bring things out. And some of the discoveries make them really happy and they tell the world about it all, "This is the greatest discovery I have ever made. "

For example, this is the story of Yanru. She tried to use laser beam to modify sometimes silicon nanowires and then you can change the color of this particular thing. Yayu spends some time in trying to figure out the features into what the dimensions of the colors of the two different materials. And then here is another example of the creativity of the students. So they learn how to control the laser beam and the idea of controlling the laser beam using a simple tiny mirror apparatus. So for someone who are curious about this, Okay, and how to use the drum to control laser beam from afar, I have another drum here. There's a small tiny mirror. So if I show the way the light, sure, and then effectively the light upon the wall and you see the drum, do, re, mi, fa, so. So if you just sing and control the laser pattern, the beautiful thing is okay. And this is invented by three students. So with a certain culture and environment, a wonderful project could be created. What I do is that I let them come to the lab. I said you just play without any constraint, try different kinds of things. About six months later, I said to them "What would you like to do?" So they go back and then they think a lot more and then one day

they come to me, “Hey, I have discovered a way to control laser beam”. And this is their way to control laser beam. Typically, it may cost 2000 dollars to control via mechanical mirror. But this one cost 20 cents. So it’s very nice. So anyway, they are going to publish the paper and tell the world about their discoveries.

So it has provided culture and environment for them to try. So in NUS, we do try to provide this kind of environment. So we group students together; we send them for competition. So for example, we have students who are on physics and we keep the students up with from biochemistry, biology and try to go for international competitions. And then he wins or whatever he learn in physics and they try to work with the partner who has much better knowledge and visions. And they come up with interesting solutions here. And then we have another example. We visit business departments, participating in the collaborating teams to come up with solutions to the work. Here we have these two ladies to come up with very clearly interesting demonstrations at Amazing Science X Challenge (ASXC).

So students like this and they go to discover interesting perspectives and to see different perspectives. The next topic is that we also believe very strongly in exchange programs. So every year we have professors in the, okay, for whose origins from Germany will bring a group of students from our department to go for this GIT, Germany Immersion Trip. So when they are there, they will visit a great university to see how the problems are solved there, how the classes are taught there and they’ll visit research institutions, the astrophysics center and they will travel to the museum to see what’s happening. And then students like Kia Boon, went to the US. He has the opportunity to take one year off to go to Yale University and spend one year there on an exchange program And then, when he’s in Yale, he took a picture of tombstone. That’s you go to the Yale University, why do you take a picture of tombstone. This is the tombstone of Gibbs. We know that Gibbs is one of the big man in physics.

Okay, he's passed away, but still we can still take a picture of his tombstone. And in Singapore, we have been trying to learn from everyone in terms of how to teach. So we also try to figure on the different pedagogy to challenge our students. For example, we try to develop minds and hands on classroom activities. We believe strongly in this. This is one of the classroom activities. For example, if you are interested in trying to teach the students the ideas of crystal structures. You know a crystal structure is very complex amd complicated, and sometimes just showing them pictures may not be useful.

So this is what we did. We have boxes. One box is made of perspex, transparent perspex, glass. So you can see everything inside the box. And then the second box is one box with 100 tennis balls. So with two hours of that discussion, we just get the tennis balls into the box. And then by way of stacking, by the way of arrangement sequence, you can generate different crystal structures. It is transparent. So you can think it up.

You can observe different facets of the crystal from different directions. This is very mindful way because two hours is very tiring for the student and professors. You only start with tennis balls. Just imagine next year. If I started with tennis ball and ping pong ball, two different sizes, it would be super complicated. Next, develop a new way to teach. We want to develop a way. Is it possible to have a star gazing class at 10 am? Yes, you can see a star at ten when there is the sun. But we can do this. So we have a special planetarium dome. So this is a dome that you had just pumped in gas and it will be like this. And then when we are ready and sit behind, we begin the project . In the center of this room, there's a seventy-thousand-dollar projector. You would project any kind of nice guy that you want.

This is a classic number of how we try to engage our students in a solid-state physics study. The picture on the top left here are smallest containers and in each class, every student draw a certain number. And then after that we asked what's

the exact number did you draw. Oh, I draw 34. Okay, this is 34. Then we give the container 34 to the students. You see that in the container is the smallest solid-state item. We don't know what it is, we pass it through to the students. And we don't care what you do, but at the end of the semester, I'm going to write a report about this mysterious item.

And we also try to do things like flip-classroom or MOOC which we still try to explore. Because it has to be done in this particular manner. The next topic, the final topic I want to emphasize on is this program is called a special program in science, in the faculty of science. So this is a pedagogical model of teaching and indeed the science curriculum for undergraduates. And so you see pictures of some of the students over there. I will spend more time elaborating on this particular program. It has been accepted for quite some time already, as you can see. It is targeted to inspire scientists with passion for science and make contributions to a knowledge-based economy in the 21st century. So this is a program that the faculty of science emphasizes on, and it is truly multidisciplinary, and very much computation-driven. They also had their own lab and very much collaborative in nature. Let me explain the program in details. First, we want them to take classes. The sort of classes they are taking as you see over there, is a very interesting type. The first module they must do is atoms to molecules.

Second module is the cell followed by the Earth, then followed by the Universe. So from very very small to the very very huge. The underlying theme of all these classes to be taught by professors will combine the thinking process, concepts, ideas from different disciplines, physics, chemistry, biology, mathematics, all combined together. So the students see the interesting inter-discipline nature of the program. And they discover science and integrative science projects are the research project they must do. Discovering is that they share some of teacher review, look at what is there, what is solved, what is the unanswered

problems or other debate problems, and they will propose some kind of approaches to teachers. Integrative science project, if possible, they will try to carry out and implement a research project with the hope of finding an answer, get to all those debates and then try to find answers to all those questions.

And the senior mentorship is one of the very, very heavy important elements of this particular program. So, special design fits to small module as mentioned, combines maths, biology, physics and chemistry. So atoms, molecules, cells, earth and universe, and we have a dedicated lecturer who will come and teach this particular set of module of this program and research-based process. So they must look research methodology and research review. And scientific communication is a very important part of this training. These students will be asked to present, present and present all the time and there are also courses on teaching them what is the right thing to do and that talk a lot about approaching our research activities.

We also have a specialized computer lab for them. A lot of opportunities for their whole year computational skills, so we have a mathematica that we try to teach them. We also try to teach them the ideas for using Python to achieve a certain result. So here are pictures of students carrying out their activities in the active learning classroom. You see that computers display. Sharing your idea is a common thing, then, peer learning through mentorship. The students who have graduated or finished the second year for this particular program, we get them back to become the senior for the junior. You can see pictures on the left here. You have the senior students explaining and engaging with the junior students. The peer-to-peer learning expected of this particular program is very important and highly emphasized. So they contribute back to the program. They have been there doing that so they know what to expect, how to do things. And then this becomes kind of role model for the students in terms of the process of going to the SPS, a special program in science.

So this is the room. So the company give them specialized space. It’s not so useful if students don’t have a special interest or you do not provide the infrastructure for them to always do together, discuss and then grow. So faculty of science sit aside, half a floor consisting of the open space, seminar rooms on the left are like this and computer lab; opposite to this room is the research that we have different labs for the students to make use of. And we have a workshop. So if they want to use the labs to figure out and make things, this is also possible for the students. And to show that our faculty’s dedication to this program, we have directors, whose job is to make sure that the programs run very well. And we hire four different lecturers as you see.

They are teaching those four specialized modules. Each of these lecturers are affiliated to corresponding departments. Take mathematics for example. But part of their teaching duties is to come and teach this particular program and they all want to engage the junior students. We have a whole list of mentors. These are seniors, very very very dedicated seniors, and they are very very hard-working and to study science. Like Kia Boon, he is doing his phd in our university working with Harry Cornell, the Nobel prize winner. So these students they do well and when they go out, they tell the world, the writers of different positions. Those professors appreciate the delegations and the talent of these college students bring them great opportunities to develop their further studies.

So how do we admit theses students with passion, attitude, commitment, team-player and open mind. So it is truly a tough process. Every year hundreds of students would like to apply for this program, and altogether about 40 to 50, and every student have to do an interview. It is an interview panel. A panel consists of students, seniors, directors and lecturers. The interviewee will come in and they will have to answer all kinds of questions, different science questions,. So this is the SPS program. It’s always very interesting for students, and then in my view this

is very useful to train young college students.

Ok. So I hope I give you a world view about some of the program examples that we try to do in Singapore or free samples that we used to teach. Thank you very much.

Shift in Paradigm in Engineering Education From Single Technologies to Systems of Systems

Ramon A. Wyss
Former President of KTH Royal Institute of Technology

This talk deals with the shift in paradigm in engineering education, moving from a focus on single technologies to the need of dealing with entire systems. I want to bring to you this idea of a profound change that in turn reflects changes in societal development. To do this, we start from a brief historical reflection about the context of engineering education. Whereas universities have existed over a long span of time, education of engineers is of rather recent origin. It is connected to the industrial revolution and one may state that France is the origin of science based engineering education established in the aftermath of the French revolution. And then I want to address something that we call challenge-driven education (CDE). I don’t want to use too many words when describing this name, only phrase it. When you phrase something, you find immediately that some other people use similar names and under different circumstances. But I think it is a concept that you can incorporate into the curriculum. I don’t think that all courses of your curriculum should be in that fashion, but you should attempt to have at least one course during the studies in your bachelor program that should incorporate that kind of philosophy. In fact, our university has a corporation with Shanghai Jiao Tong University since many years back. Within this cooperation, annual summer schools

for PHD students have been arranged, where some of those were attempting to incorporate this concept. I will address this topic in the second part of my talk.

Let us start with one of my great fans, Richard Feynman. You can find many quotes from him in his books. There is a message for our students that we should always keep in mind, and that I want to share with you: 'you have no responsibility to live up to what other people think you ought to accomplish'. Often our students think too much about what their parents want, what are the ambition of my parents, and not about their own passion. I think if you really want to achieve something, only your own passion will pass the test of time. The other quote I wish to share says that 'religion is a culture of faith, and science is a culture of doubt'. And sometimes, I think, even when teaching science, we may mix these two things, and that we present science as too much faith-driven. To allow students to doubt and question is very important. So, thanks Feynman for those thoughts.

If you ever visited Stockholm, you should not miss the Wasa Museum showing a battle ship. The vessel was built in 1625. It was the supposed to become the lead of the Swedish Navy. At that time, Sweden was a big power in Europe, and the ship was ordered by the king himself. When he saw the first design he found it not big enough and ordered to have it enlarged. It eventually became ready in 1628. And then you can view its historic records. On her first maiden trip it did made more than a thousand meters before it sank. This is why it could be discovered in the mud close to Stockholm some 60-70

years ago. When one happens to see such a big vessel, you may wonder how could it be constructed at that time? In former times you would not need engineering; you learned your craft, and it was passed on from father to son. At a certain time, you may realize that you need some specific knowledge to replicate something and to understand how e.g. a big battle ship can keep its balance on the sea. This is where engineering starts. You have to introduce science into the craft, that's also the beginning of industrialization. And as mentioned there, in France particularly, Napoleon started the Ecole Polytechnique, that hosted the greatest mathematicians and mechanics of that age, combined engineering and science and gave industrial development and construction a scientific base. The guiding principle for engineering is design based on scientific evidence, the methodology to reproduce products according to certain scientifically verified rules has been a cornerstone to engineering education since the beginning of Naval Engineering.

From then on, one can see how quickly shipbuilding has evolved, new materials were introduced like steel, the steam engines and so on. In the 1912, famous claims were made that one can build ships that are unsinkable. One may reflect here upon our hubris when it comes to technology and the solutions it may provide. This rapid technological development has defined the engineering profession. You improve step by step what has been done previously. You improve the diesel engine and make it a little stronger a little more efficient, improve the material of the steel of the ships, increase its size, improve speed. The development has been driven by the development of each subsequent component of the vessel and it has been highly successful. This concept of reduction to single components has also been defining engineering education for quite a long time, even now. This aspect, I want to address in our discussion.

Now if you look at the most important naval innovations in the 20th century, you can go to a port for studies. Realizing that the purpose of ship building is

transportation of goods from one part of the world to another, i.e. a service based on a system. You look at modern ships that can drive the fleets between different countries in global trade. And then you realize that the most important invention for shipping is a steel box. It has really revolutionized the trade in a way that all kind of innovation within ship building has not been able to accomplish. Today's volume of trade would not be possible without the help of the steel box, 'the container', that has simplified the loading and unloading of ships in an unprecedented manner. And the inventor Malcom McLean, was a businessman,

not an engineer. He developed it the shipping container. He was the owner of a company and patented the steel container in 1956. It really has revolutionized trade. This leads us to the question of talent cultivation. How can engineers think outside the box? What are the consequences for engineering education? In your work as an engineer, you are responsible for your design task, but you should also see the entire context and the system in which your design is embedded into. How can we develop engineering education that supports system knowledge, enabling the graduates to leave their comfort zone?

When we think about the future of transportation, we know that we are facing one of the largest challenges of our time: The emission of greenhouse gases, and the challenge of climate change, where you see the transport sector really has a big part. According to a recent paper two years ago published in Nature, it is shown that if we intend to follow the climate agreement of Paris, then we have only three years to safeguard our climate. According to the Paris Agreement, we should not

increase the level of carbon dioxide in the atmosphere beyond to 400G tons. It implies that the integral of our emission needs to stay below that point. We need to develop technologies that can decrease emissions. This constitutes a challenge for engineering and science, how society can change its emission based economy. The authors of the paper claim that we may be able to increase our carbon budget from 400G tons to 600Gt, which will give us a little bit more time, but it means also accepting a larger risk, that the temperature will increase. For further reading see: Three years to safeguard our climate; Christiana Figueres, Hans Joachim Schellnhuber, Gail Whiteman, Johan Rockström, Anthony Hobley and Stefan Rahmstorf; Nature Vol 546, issue 7660

When discussing naval engineering in the context of climate change, you realize that there are different levels of challenges. We face a system challenge that engineers will need to address. We cannot anymore limit education to improving isolated components. Engineers will need to set their profession into the context of a system. And that means, for example, how can we have carbon neutral transportations. Challenges can be e.g. whether we can develop zero friction motion and solar drive. How can we develop the transport sector to be fossil-free? That is a system challenge for engineers. It means that engineers have to work across borders. Our goal becomes the development of a sustainable transport service system. This constitutes a system within systems. This is both a great challenge and opportunity for engineers to envision your role in this work with

others. Of course, the most beautiful system of all systems is shown in this figure and we all need to take care of it.

The United Nations agreed on the 2030 sustainable development goals (SDG), see https://www.un.org/sustainabledevelopment/student-resources/ They constitute the global challenges of our time. How can we address them? I think science and engineering, but also business can contribute to many of those. To achieve a change and start to work on solutions for those challenges, they have to be brought into the curriculum of all students. I strongly advocate that education, research and innovation in engineering science is important to achieve the SDG and mitigate climate change. It means that universities have to take upon this role, as a leader, as an innovation powerhouse that needs to drive this development. Hence, what we frame as challenge-driven education can be seen as a tool to incorporate system challenges, and it can also be a tool for international corporation. I mentioned already our cooperation between KTH and SJTU.

We define challenge-driven education in a specific sense, as a framework for learning while solving real-world challenges. The implication of challenge driven education is that students work on something that is a real challenge of the world. It is not a Challenge given to you by your professor, but is defined by external stakeholders. It is collaborative and hands-on. It is asking participants (students and stakeholders) to discover and solve challenges, gain in-depth knowledge of the challenge by which they are encouraged to develop their skills, subject area knowledge, and engage with the world outside of the university. The starting principle of challenge-driven education is the interaction with external stakeholder. They can be e.g. the city of Shanghai, or the municipality of Minhang, or an NGO. It can be a business partner who proposes a challenge and owns the challenge. Through engagement with the stakeholders, students are encouraged to develop solutions. Hence, challenges are defined in collaboration with society

(private sector, public authorities, civil society), and then further refined and turned into actionable problem statements. From the problem statements, one or more solutions are developed, tested and implemented. An excellent method to work with challenge driven education and stakeholder interaction is to use the steps of design thinking method, see e.g. https://openlabsthlm.se/professional-courses; https://hpi.de/en/school-of-design-thinking/design-thinking.html

So why do we need this challenge-driven education? Too often, university education centers on problems with given solutions. Educations trains students to solve problems. There is little focus on the relevance of a problem. How do we know that we work with the right problem? How do we know that the solution is viable and desired, not just a correct solution to the stated problem? If it is the wrong problem, then our solution is irrelevant. There can be many correct solutions to a stated problem — not all of them are viable and desired. If the solution is not viable, then it will probably never have any impact. To look at possible impact of your work is much related to talent cultivation. Students want to make an impact in their future life. We need to have this in our mind in education. Challenge-driven education is something that wants to achieve social impact. Education becomes linked directly to impact on society. The challenge is defined by external stakeholder, and the end results aim at becoming beneficial to society. The relation to society, to external stakeholders constitutes one of the differences to problem-based learning. To achieve direct impact with education requires an open response from society. External stakeholders need to learn to interact with students and academia at large.

There is a theoretical background with respect to societal challenges. Design theorists Horst Rittel and Melvyn published a paper in 1973, where they described problems in society. They framed the term “wicked problems.” Scientists are often used to well-defined problems which have well defined solutions. This is in general

a one dimensional process. On the other hand, societal problems don't have a given solution. There are many, many solutions. It means students have to open their mindsets in a different fashion. In the general educational framework, we discuss problems and we know the set of solutions. Professors always know the solutions. For the case of societal problems, professors do not know the solutions. As a teacher, you do not know the solutions of societal problems, because the space of solutions is so large. To understand this brings a very important aspect to education, which will become more important with time. In a previous talk we heard how our lifetime expands and that many of us will reach hundred years and more. Many of us will be active for even 60 years and more. It means we need to learn working with open problems.

So the characteristic of a challenge lies in the problem, i.e., we talk about it in terms of finding solutions and that there can be many. It is complex. There is not even an obvious process of finding solutions. There are many potential solutions. The challenges and the solutions exist in a social, technical and environmental system. The problem space is open to engineers, natural scientists, social scientists, businessmen lawyers and more.

In order to find a solution to a challenge, we need to understand the challenge. We need to do that together with the stakeholders. We need to understand the system and the beneficiaries, so that we can define a relevant actionable problem, because at the end we have to work with different problems, develop different solutions. It is an interactive process that we have to gear towards the stakeholders and understanding their view point.

Let us return to the challenges of our time, the UN sustainable development goals. If our graduates are not capable working with those challenges, who else will? We have, as a teacher, the task to provide our graduates with the skills that can turn those global challenges into opportunities of the society.

I want to illustrate the process with two examples. One is from a project course in integrated product design. The starting point is team building. This is an integrated part of challenge-driven education. You cannot solve a challenge on your own. You need a team. You need many people working together. When the team represents different disciplines, it is even better. You see the picture of team building, where the entire team has to cross a wall. The last guy will have difficulties and everyone has to help each other.

The challenge this team was facing was presented by a company, namely to address the challenge of flooding and how to construct a movable pump. The requirements posed by the company was a flood pump that can pump 100 liters/second of dirty water. It has to be easy to put apart and to assemble, and the weight has to be less than 50kg. This was the challenge. There are many solutions and it is a real-world challenge. The student team managed within this half-year part time course to build a pump. The final weight was 36kg, and it could pump 120 liters/second, fulfilling the requirements. The prototype was taken up by the company and developed further. We understand what confidence and experience students gained by building such a prototype.

Last year, we further developed the concept of CDE for international cooperation with countries in sub-Saharan Africa and universities there. We bring together teams of students from Sweden with students from our partner universities. There are many challenges related to the SDG and we require that the challenges are owned by external stakeholders, by an NGO, a city, a company. We start with a workshop with the stakeholders, a ‘challenge definition day’. Following the workshop, teachers and stakeholders develop jointly challenge statements. Then students and stakeholders reframe the challenges. In the process peer learning and co-creation are introduced. The starting point is always real-life challenges, external stakeholders, and students as agents of change. The teachers are more facilitators and

experts. The solutions provided by the mixed teams from Sweden and e.g. Tanzania will hopefully contribute to the solutions of the SDG. In this fashion it also helps society to develop interaction with universities, with students. For more information, see [1,2]

How can university courses contribute to sustainable development? The basis needs to be within the teacher training program, where the aim is to learn about the sustainable development; how can it be integrated in courses; what is sustainable development for engineers; what is learning for sustainable development; course goals, activities and examination and so on to stimulate reflection among the teachers how sustainable development can be integrated.

Let us return to challenge-driven education for talent cultivation. I think it is much about developing solutions to "wicked problems". One important outcome will be to open the mindset of students and teachers alike. And it will affect the stakeholders that you engage with. KTH has worked for many years with challenges posed by the city of Stockholm and the city has had a great learning curve. The city learned that working with students and teachers brings entirely new experience. It further develops the students' confidence towards problem solving. They realize that together with some other students 'we can do something on our own and achieve certain goals'. This confidence is another important building block in talent creation, i.e., the trust in yourself and your own capacity. It has the additional advantage to start working outside the box, i.e., to boost creativity. Students have to formulate their own solutions. It is not about teachers telling you how. Particularly, the open problem space with so many possible solutions. It also brings a system understanding because you work in a societal context. We may call it education for societal good and creating this interaction between academia and society that is so important for the knowledge society.

Let me conclude with two quotes. One is from Einstein and it is very nice

quote: “Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to how understand.” This is an important message for our students to understand and realize.

I got from my daughter the last book from Stephen Hawkins which I read on my way here, ‘brief answers to big questions’. I was enchanted when I read the introduction by Stephen: “I hope when going forward, even when I am not longer here, people with power can show creativity, courage and leadership. Let them rise to the challenges of the sustainable development goals, and act, not out of self-interest. I am very aware of the preciousness of time. Seize the moment. Act now.”

Guide to challenged driven education KTH web pdf file for free download: https://www.kth.se/social/files/56e2b5f1f276541778ae27f5/Guide%20to%20challenge%20driven%20education.pdf

[1] Mutual innovation capacity building through challenge driven education for sustainable development in an international setting; R. Wyss, M. Kissaka, E. Shayo, C. Mwase, A.K. Högfeldt, F. Ishengoma, H. Tenhunen; published at ICERI2019; https://iated.org/iceri/publications;

[2] Connecting North to South throught Challenge driven education; Rosén, A., Högfeldt, A. K., Lantz, A., Gumaelius, L., Wyss, R., Bergendahl,& Lujara, S. K. (2018). Proceedings of the 14th International CDIO Conference, Kanazawa Institute of Technology.

The Cultivation of Talent: Selection versus Identification

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The Evolution of Our Ideas about Intelligence and Talent

Educators have been thinking about the topic of this forum, the cultivation of talent in students, for many years. The history of this thinking, and why it has changed, is singularly important to understanding differences in the way China and the United States (US) approach designing educational programs.

In the US, publications about the cultivation of talent can be found as early as the 1860s, mainly concerning school children. William Torrey Harris began a program for gifted students in St. Louis, MO, in 1868, and popularized the connection between education and psychology [(1)]. Designs for cultivating talent are directly linked to models for understanding intelligence, so these two ideas are intimately connected.

Historically, we believed that intelligence was intrinsic. In the 1860s, Francis Galton used statistical correlations to conclude that intelligence had a hereditary link [(2)]. If intelligence is an intrinsic, even genetic, characteristic, then either "I am smart" or "I am not smart"… end of the story. In this model, if we can figure out

how to sort the population based on their intelligence, then we can allocate jobs and resources according to talent and skill.

For about 100 years, we believed three important things about intelligence, all of which are incorrect. First, as stated above, we believed that intelligence was an intrinsic, genetic trait. If you are smart, you were born that way. Second, we believed that intelligence was a stable trait. If you were smart yesterday, you will be smart tomorrow. And third, we believed that intelligence was transferable. If you can solve a chemistry problem, then you can also solve a history problem.

This model of intelligence is naïve. There are times when intelligence appears to be inherited, stable, and transferable, but these are coincidences rather than causes, and features such as family, cultural environment, and experiences play more of a role than genes or intrinsic abilities.

Not surprisingly, when we believed that intelligence was intrinsic, we immediately began to seek a system for measuring intelligence. If you can define a quantitative scale of intelligence, and if you believe in “intrinsic intelligence,” then you should measure children. And then, you should use the predictive value of “stable intelligence” and provide the gifted children with greater opportunities to develop their talents. And then, based on “transferable intelligence,” you should put them in positions of influence and leadership.

In the early 1900s, in France, Alfred Binet and his student, Theodore Simon, developed the concept of “mental age,” namely, to answer whether your intellect was ahead or behind your physical age. They created a test that they could administer to children, so that the intellectually inferior students (by their definition) could be put into special classrooms [(3)]. And in the mid-1910s, Professor Lewis Terman, a noted educational psychologist at Stanford University, built upon their work and created the Stanford-Binet Test. The dimensions of intelligence that are claimed to be tested are typically collapsed into a single numerical value, the

ratio of your "mental age" to your "physical age" (mental age/physical age x 100), which is called the Intellectual Quotient, or IQ.

Giving an IQ test, or using standardized testing with the rank score, in general, is comparable to running a race. You define the conditions for success, then you run the race, then you use the results to select the first place winner, the second place winner, and so on. No judgment about the individual and the individual's experience matters, only the results from running the race.

Your model of intelligence is extremely important because it dictates your design for its cultivation. If you think intelligence can be measured in a ranked test, then you will spend lots of time preparing for testing and caring a great deal about your ranking. As an educational designer, you will create programs that define success as exam performance and doing what it takes to achieve a top score. Once you define success as a race that you need to win, then you know what to do to prepare others for it, and you will wait around at the finish line to see who crosses first.

Although the race-running and testing model of intelligence has been largely discredited, people believed it for many years. And many of society's behaviors still reflect this naïve model of intelligence: we give a lot of credibility to the opinions of people who have been successful in one area, believing they have something important to tell us in another area. Yet, just because someone gets a Nobel Prize in Physics does not mean that we should get their opinion about literature, or about politics, or about what car to buy, or about what cereal to eat for breakfast. Still, we do this all the time. In fact, we are not even too selective about intelligence in getting recommendations and opinions, as we are just as likely to take advice on what to buy from some famous person, a sports star, an actor, or some other celebrity, as we are from a Nobel Laureate.

The Change from Race-Running Selection to Identification of Traits

In the 1970s, there was a significant change in the literature for how to cultivate talent because our understanding of intelligence was also changing. Over the last 40 years, our models of intelligence have evolved rapidly. We have created concepts such as “cognition” to treat intelligence as a developmental process. We now care about how we turn our external and internal experiences into understanding, and how our cultural and environment (“context”) dictate how we value and interpret what we see and do. We understand that the same person who might have two quite different life experiences also ends up with completely different characteristics and skills. People can only build upon their past experiences, and their thinking about those experiences, when they encounter new situations and challenges.

Intelligence and talent are not stable. They respond to context. If I take one person with some kind of potential, and then put them in one environment, they are going to do different in that environment compared to another environment. And because they have free choice in how to respond to their environment, they can not only define their own talent, but also modify their environment to achieve different goals. Intelligence is fluid and adaptive.

Interestingly, the greatest number of papers written on the cultivation of talent during the past 10 years has been in the area of sports athletes [4-7]. As with intelligence, we believed that athletic skill was intrinsic and stable, and so we quite literally could run a race and pick the winner. And that process may have predictive value in the exact same race, if it is run tomorrow, but not so much at all in a different kind of race, 20 years later.

Also interestingly, the modern US literature on cultivation of academic talent is still mainly concerns working with children. You find almost no publications

about cultivating the talents of college and university students. People do believe that the most important time for truly cultivating talent is when children are young and building their habits for learning. As educators, our job has shifted from running races to creating environments and providing experiences for these young people to grow in.

One of the most confusing and contradictory things to happen in the US in recent years is how institutions (school systems, schools) have increasingly defined their success based on standardized testing [8], but how, in contrast, the admissions process (university, graduate school) have almost completely abandoned testing as a significant criterion.

Testing can tell you if a person knows something about what is known, but if intelligence is not intrinsic or stable, then you know nothing about the values in which you are actually interested: how will a person deal with the unknown or things that are ambiguous? How they will face uncertainty? How they will face failure? How imaginative or create they will be? What sort of intellectual and organizational leader they will be when called upon?

The selection of talent through testing attempts to be a science. You assume the measurement has meaning, and so you take the results as accurate and reliable. Testing certainly predicts success for the narrowly defined known, but the only way it can be used to extrapolate is if your model of intelligence assumes that you can test for it, and that intelligence, once measured, is stable and transferable. Selecting people through testing is not meaningless, but its value is extremely and strictly limited to the topic of the test.

The identification of talent is much more like an art, because it is about the identification of personal character. You want to know what are the experiences of an individual today that will lead to success tomorrow, in an area where they likely have no ability yet. We think that how they responded to situations in the past will

predict their ability to respond to their environment in the future, we can anticipate how they might respond to coaching, and we can see how they are going to respond to something new and unfamiliar based how they have responded to new things in the past.

The identification of talent, as opposed to its selection, is not easy. You cannot just give a test. It costs lots of money. It is extremely demanding on resources. You need descriptive materials of student experiences and you need to carry out interviews. And almost impossibly at the outset, as an interviewer, you need to have the particular skill to identify what are the characters of an individual who will have these successes in the future. And if you are the interviewer making these highly subjective decisions, then you are open to your personal bias. You will likely tend to want to identify the people who are most comparable to you.

Starting in the 1970s, the literature on gifted and talented students moved away from testing. Here are the criteria that teachers were advised to use to identify talent in 1975 (9):

(1) What is the behavior of the student as a learner? Characteristics to watch for: does a student use advanced verbal expression? Do they embrace new challenges and are they insightful observers? Does the student use analogies extensively to help make their ideas comprehensible to others?

(2) What is the behavior of the student as a person? Characteristics to watch for: Are they persistent and flexible in the face of complex tasks or failure? Are they organized and can they anticipate possible challenges? Are they assertive and can they defend their position with persuasive arguments?

(3) What is the behavior of the student as a creator? Characteristics to watch for: Do they take risks in the face of uncertainty? Can they think non-dogmatically, questioning assumptions that others do not and are they comfortable with non-conformity? Can they generate multiple solutions based on an analysis

of alternative assumptions? And are they a person who sees humor in things that others do not, because people who see humor can often quite flexibly identify multiple conditions for a situation simultaneously, and some of those situations end up absurdly funny.

(4) What is the behavior of the student as a leader? Characteristics to watch for: Are they confident in having a defensible position? Can they be persuasive to others and get others to adopt their point of view? Can the person make a good plan and then follow through with it, including delegating responsibilities as necessary to meet the goal, sharing credit and risk in rational ways?

Just look at those four items! These are not the things that are tested on an SAT, not the things tested on a GRE, not the things tested on A-level exams, and not the things tested on the 高 考 (GaoKao). And yet those are the categories, in a world where intelligence is not intrinsic, that we believe are needed to identify talent. Not only are these items not on any the exams, but they are things that cannot be tested for at all, using any exam. It takes a person making a value judgment to make this identification; it takes experience for the student to express their experiences; and it take experience to read and evaluate this kind of information in a meaningful way.

Using a test is easy. But if the information is actually useless, it truly does not matter how easy it is. And inventing an excuse, such as “well, it is better than nothing,” is wrong. If you use a test that does not identify talent, then you are going to dismiss some genuinely talented people because of their low ranking on that exam… and the good test-taker may well only have the talent of being a good test-taker.

The only way you can use the ranked results from a standardized test is if you believe intelligence is intrinsic, stable, and transferable. And so, in US higher education, there has been a dramatic movement away from SAT and GRE scores as

having any value at all, and a movement towards “holistic evaluation” of complex student records, including descriptive experiences and what they and others say about them.

China and the US

When China began to rebuild its system of higher education, from the bottom-up, in 1977, the historical model of intrinsic intelligence existed. Indeed, the classical Imperial model of education in China was not only built upon demonstrating success on testing, but also upon a kind of prescriptive assumption that genetics (being part of the Imperial lineage) is what mattered the most. The intellectual leaders were literally born into their positions.

Even today, the first generation (Class of 1977) is still rebuilding the higher education system one year at a time, 40 years later, from their positions of leadership. The rate of change has been both dramatic and impressive, and it is easy to be impatient.

A significant flaw that still remains in the Chinese system is that its precollege schooling appears to be so completely isolated from the ideas that have emerged about intelligence. The model of intelligence that exists, today, in China, is still based on the belief that running a race and making a selection of the winner can be used to identify the talent for the next generation.

At best, this idea is naïve and outdated; at worst, it will hold back the true growth and development of the Chinese intellectual capacity and contribution.

The changes that are being attempted in the major Chinese universities are exactly the right thing, particularly the various Honors programs that begin to provide students with choice and opportunity. But there are still major hindrances: (1) the system of selection and ranking still indicates a belief in the absolute

nature of intelligence; (2) the precollege system is even worse, and the teacher training and school systems are still built around these ancient beliefs; (3) nearly every person in higher education who is a professor or an administrative leader is the product of that same system, and so they will resist changing the system that selected them.

The author has had great fortune, over the last 20 years, to be teaching students in both the US and in China including, in particular, students at Peking University, Nanjing University and Shanghai Jiao Tong University. It is absolutely true that the undergraduate students in China have much better content preparation than their counterparts in the US. Truly: much better preparation in the subject matter, and a singularly better skill-set for a certain type of learning.

In the US, the high school system, overall, is simply horrible. Teacher training is inferior, and the lifetime of a teacher in the school systems is typically short. And things are getting worse, not better.

Students in the US enter college in a very different way than the students enter in China. In general, Chinese students enter with a decision about their major, and they often have testing to back that up. While sometimes they can change their minds, it is still not the rule. In the US, students are "undeclared" for two years and we don't care; we encourage open and free exploration across all fields. Students in the US can decide on Monday to be chemistry majors, and on Tuesday they change their mind to be a history major. That is okay. And on Wednesday, they change their minds again. Maybe they want to become chemistry majors again; maybe they want to design their own environmental chemistry major. Just fine! The only thing that matters is what happens at the end: not what you intend to be, but what you end up becoming. The major is truly decided at graduation.

The co-curriculum for students in the US is significant[(10)]. Students take organizational and leadership positions. Not just clubs… but significant activities

for the university community, for the regional community, and often for world citizens. Students at the author's institution have proposed and taught credit-bearing courses, albeit under the supervision (although not necessarily the direction) of a faculty member. Academic success is still important, but nearly all students can point to their experiences as a learner that go beyond the GPA… their experiences as a person in a collective culture… their experiences in having created something new… and their experiences in developing and leading some sort of unique activity.

Previously, the author has published three criticisms about the Chinese university education system (11), and it seems most people agree. (1) The Chinese universities do not take advantage of the subject matter preparation that their students have. Chinese students are so well prepared that many of the introductory courses are repeating the same things they have heard before rather than building upon them. (2) The Chinese university students should be pushed much higher; they can handle more, particularly in the sciences, where it is possible, in 2019, to bring actual research activity into the teaching laboratories. (3) The Chinese university students take too many classes. The students have no time to think. And they need time to think, and they need interesting things to think about.

Remember this one fact: the US students are quite competitive with their Chinese counterparts in getting into the US graduate programs. Yet the US students may only have one-third the number of courses, and far fewer hours in class. You have to answer the question: how can the US students be competitive if they take significantly fewer classes? For sure: it is not necessary to have all those classes. Not so many hours sitting in a classroom every week.

In the US, we have strongly encouraged undergraduate research starting from the time students enter the university. At the University of Michigan, 25% of the entering students, all across every field, are supported to get involved with

faculty research – from chemistry to history; it does not matter. And they are paid for it. The provost office allocates 5 million US per year to support at least 25% of all entering students to get involved in research, so they do not have to work at McDonald's.

Honors programs in the US are also a relatively open choice for students. The main purpose of the Honors programs is to provide opportunities to develop those key behaviors, through experience as a learner, as a person, as a creator, as a leader. The entering students are not overly selected based on their high school achievements, because it is not assumed that those high scores will automatically create success in the university setting.

There are also different honors options. At the University of Michigan, the department of chemistry exists in the large Liberal Arts College, which means chemistry is just one of 75 units in the College. Our Liberal Arts College admits 4500 students every year, and the top 15% of those students are simply invited to be part of the College honors program. And so, as a student, you can decide if you want to participate, take some special classes, and maintain your GPA above 3.4. There are also honors options in the department itself. We can offer honors versions of our classes or honors options as part of the class. We offer honors degrees. Once again, what matters in the end is what the students have accomplished, and they are the ones who make that decision. They show their talent to us because we create an environment in which they have choice and flexibility[12, 13].

The Role of Culture and Experience Makes It Extremely Hard to Change Quickly

There are five changes that need to take place in China at the same time, and that makes the situation much (much!) more difficult than simply learning about

the US system. (1) The curriculum design needs to be less strictly defined, updated, and more flexible. (2) The culture of expectations that the students have needs to change (after all, they have had over 12 years of testing and ranking before they arrive at the university). (3) The culture of the faculty expectation that the education they provide is like the one they experienced needs to change (otherwise, the system just reproduces itself). (4) The plan for pre-college education and training teachers needs to change to reflect a different model of intelligence. And (5): develop patience! The change cannot be declared as a revolution, but it must evolve, starting from the place where it currently exists.

I need to shift to my personal experience to make the remaining points, because I am equally guilty of reproducing the experience that I had as a student. As a student, I was in a system, before college, that was quite flexible, and where I had lots of choice. In college, I had to make all of my own decisions about what to take, about when to take them, and what my electives might be. In my classes, I had projects and open choice, starting quite early, to explore and do research, even if only on a small scale – it was still an actual unknown, and I was designing new experiments.

All the while, my professors had their eyes on me. I know now that they were watching my behaviors, the independent decisions that I was making, and not only the fact that I was getting good grades. I was identified for the potential that I was demonstrating, and then put into new situations to see how I would do; I was not selected merely because I had a good GPA.

As a professor, I now copy this behavior. Part of my job is to create situations where I can observe the learner-person-creator-leader characteristics of students. And none of those things happen on a test!

There is a standard idiom from Chinese culture about identifying the hidden talent, and how special is that skill: 伯乐相马 (BoLe XiangMa).

伯乐 (BoLe) does not make a selection of 千里马 (QianLiMa). If so, 伯乐 (BoLe) would set up a 1000-mile race, draw a line, and see who finishes first. Any idiot can do this because selection is easy. The real trick is seeing the horse right now and knowing who can be the 千里马 (QianLiMa).

It takes 伯乐 (BoLe) to identify. And I say that our job, as professors, is the job of 伯乐 (BoLe).

If you believe talent is intrinsic, then you run a race (give a test) and see who wins (give a rank). If you want someone who can take what is known and do that job tomorrow, then that is exactly what you want to do. That is selection; but that is not the job of 伯乐 (BoLe).

Identification is the creation of opportunities for people to develop and demonstrate a talent; we are making a judgment about the potential that might appear 20 years later (or 1000 miles later).

Selection versus identification: I am using these words because these are used in the literature of gifted and talented students, but what I am really talking about is the battle between nature and nurture. Is talent intrinsic (nature), or is it something that can be developed (nurture)? Of course it is a balance of both! You cannot ignore either one. If we have a person with great potential (nature) and we create a poor environment, then we will not nurture them. And if we use the wrong criteria to identify talent, such as testing, then the demands of the environment will be too much for them. We may not be able to ask a good test-taker, who learned that test-taking skill over 12 years, to suddenly be creative. They have no experience, and because intelligence is not intrinsic, stable or transferable, there is no reason – at all! – to expect a good test-taker to do anything other than to be able to take tests.

I have grown up in an identification culture. I was fortunate to be identified as a gifted, talented student. And I spend my career being 伯乐 (BoLe). I have the eye of 高伯乐 (Gao BoLe), but it is a practiced eye, with experience that goes back to

the time when I was a student.

Based on my experience, I can design curriculum that will allow those 千里马 (QianLiMa) to show their talents. And I am biased too. If somebody told me I had to do testing and ranking, I would simply say no, because I cannot learn anything useful.

Chinese and US Students in the US PhD Programs

In preparing this report, I have asked my colleagues what about the comparison between their new Chinese students and their new US students in our PhD program. During the first year, they say “I love the Chinese students. They have such strong mastery of the subject matter, the technical talent and the laboratory skills. I only have to say something once, and then they are in the lab doing it.”

What happens later when it comes time to develop a new idea, a new technique?

The US students are not automatically better, but they are much more comfortable with trying out some crazy ideas. The Chinese students can do well in these new situations, too. In the opinion of my colleagues, it is the personal character of the students that matters the most. One of my dear colleagues used this term that I love. He said that what our students need is “naïve courage.” Naïve courage means they do not know everything, but they think they can do anything. They just give it a try. And if they are living and working in a culture that supports this kind of open thinking, then they will do it and not worry.

This is where the culture of the environment matters. If you are in a selection culture and your student comes to you with a crazy idea, you might say, “that’s a crazy idea and it will not work, go away and do it the right way – do it my way”

because you're biased by your own knowledge. In an identification culture, the students come to you, and maybe in your head you go "that's a crazy idea," but in fact you say "give it a try, see how it goes and let us see what happens." Quite rapidly, you stop thinking these are crazy ideas; they are just ideas.

In PhD programs, there has been a change in language that I object to very strongly. And it is the language that graduate students use in their relationship with their advisor. Everybody in the world asks this when they talk about their advisor: "Who's your boss?" I hate that. When I was in graduate school, I "worked with an adviser." I never would say "I work for my boss;" I never even had that idea. And I think if I ever said "working for my boss," my advisor would have hit me.

As academics, we care about the PhD students because every single new professor will come from these students. We are responsible for the next generation of professors because of the environment we create, and the battle between selection and identification is critical. It is fair to say, I think, that no one cares if a new professor is good at taking tests. Even research productivity, while important, is not the most important outcome from PhD programs, because this is the only place where the new professors come from[(14)].

My advisor, Professor Barry Trost, a world-famous research professor, always said that research is not the primary outcome from his job; new scientists are the outcome. "If research results are my primary outcome," he would ask, "then why do I do it with inexperienced scientists? If research outcomes were my primary goal, then I should only hire post-docs to get the research done. My job is to help educate the next generation of scientists as best as I possibly can do." [(15)]

What to do?

Our goal, as educators at every level, is to develop the next generation of

talent. As academics, this is our unique responsibility. No one else in society does this.

So what to do? I think that China needs the 伯乐方案 (BoLe Project) – a way to change the thinking around developing talent that involves the curriculum, the students, the professors, and the school system.

This has to be a multi-generational project because it is a radical change in culture. And in China, better than in any other country in the world, you understand that the strategy of a fast cultural revolution can be a bad one. You have to be patient. You have to think in the long term. It needs to be a 30-40 year plan, not a 5-year plan.

The first objective is working with what you have and changing what you can.

What China has are students that have some really good subject matter and technical talents when they enter the university. So build upon these strengths.

Number One: stop all the testing and ranking; just stop it. Frankly speaking, if you think I care about it, I do not. So whom are you doing it for? If no one is using that information to make any decisions, then it is superfluous.

Number Two: reduce the demand of the academic programs; give students time to think and give them something interesting to think about.

Number Three: the first best place to make real change in the sciences is in the experimental classes. In an experimental class today, you can take advantage of modern equipment. Modern equipment allows you to do actual research in the experimental classes. It is possible. There are so many places in the US that now integrate research into the introductory experimental classes. Research does not have to be finding a cure for cancer. Research can be just a small unknown, and students can do individual data collection with these inexpensive modern instruments.

I have seen laboratories in China using equipment and doing activities that

were already old when I was a student in school! Modern equipment allows for the collection of real data, quickly, and on small quantities of materials, which means students can pose questions, and design research, as first year undergraduates and on a very large scale. It is easy to do; you do not need to make big curriculum changes. But the faculty members need to be willing to give up the old ideas about their experimental classes.

Number Four: increase the number and diversity of co-curricular options, such as peer-led instruction and service activities, where creativity and leadership and problem solving can be developed on meaningful projects.

Number Five: I advocate adopting the principles from a model called Transformational Teaching.

Transformational Teaching[16] has three core principles.

(A) We use information to promote the mastery of concepts. This idea seems easy, but it means that you always have to ask students to apply what they know to some new and unfamiliar information, not only ask for a repeat of what is known. In first-year organic chemistry at the University of Michigan, which we do with our freshman class, all of our exam questions are based on literature examples that we instructors never saw before, until we were writing the exam. We ask the students, from the first day, to apply the ideas, not merely to remember them. You cannot say to students "you have to apply concepts" and then give them a test where memorization works. Memorization has to fail as the only successful learning strategy.

(B) The students must develop new learning skills. They must move out of their comfort zone and prior experiences in learning, and then move into settings where they develop new learning skills, particularly from teaching and learning from one another.

(C) Students must gain what are called "learning related attitudes, values and

beliefs.” For instance, as a science educator, I believe that I should be promoting scientific skepticism. This is an important goal in science. As science educators, we want to promote critical analysis: to look at something and ask “do I believe this argument? What is the evidence?” So where does skepticism appear on your class syllabus? Nowhere! But skepticism should appear every day, because an active scientist is up in front of the class, talking about data and about experiments. Hopefully, our natural practices as scientists, such as skepticism, will come through.

If we are authentic as instructors, then many different things that never appear on the syllabus will be part of our classes: comfort with ambiguity; tolerance for uncertainty; learning from failure; defending claims; leadership. These are all those kinds of behaviors that are used in the cultivation of talent. These need to be part of the course. Although these things are never part of the explicit syllabus, they need to be a firm part of the curriculum design. These are the “learning related attitudes, values, and beliefs” about science through which we can cultivate and identify new talent.

China can make great progress in education, but nothing can change fast. Decide on the easy things to change right now, which have to be more than the curriculum items. People have to change, too: administrations, faculty, and students, starting with some new ways of thinking about intelligence.

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New Challenges and Requirements: Modern Life Sciences Education in Comprehensive Universities

Hongwei Wang
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Today what I'm going to talk about is just some of my personal perspective about what we should do from my major in biology, what we should do for the current challenges and requirement that we need to do for modern life science education. Most of the content that I'm going to talk about is mostly about kind of a dream that we want to do. Certainly there are a lot of things we haven't done yet and hope that I can learn from all of you and in the future we can discuss together about how we can make the education more on biology, more cultivating for the future, either in the life science and biomedicine, scientists, and career development as well.

I was just introduced by the chair of the session. I'm currently the dean of School of Life Science at Tsinghua University. In the past few years, I have been thinking about what is the current status in life science that actually demands the reformation of our current biology education in the higher education system, especially in the top universities here in China. So I think there are a few things we should think about the current status in life science. The first one is the transition of life science and biology from a more descriptive science to a quantitative and

precise analysis. The second one is now we are really, in life science, trying to strengthen the integration among the sub-disciplines within the biology itself. And also there is emphasis of interdisciplinary research between biology and many other fields, including mathematics, physics, chemistry, and even the computer science as well as engineering. Also, biology has become to have more impact in our society and our attention. Certainly, for our education, we should also apply and introduce new media and new technology into education. So I'm going to talk about from these five aspects what we should do for the modern education of biology.

The first one is about quantification and precise analysis. So from what I see right now, our biology depends more on mathematics, physics, statistics and computer science. For instance, this is a just a paper I got about two years ago. It's a system biology paper. This paper did not go to the detail of the story, but it uses a lot of mathematics and also statistics as well as big data analysis. It uses computational skills as well. So really biology nowadays is not just descriptive. It's really more about how we quantify and even digitize the data, and then analyze it in a more accurate way. And mathematical and scientific induction and deduction all also become more and more important in modern biology studies. So this is just a kind of Michaelis-Menten Equation for mathematical analysis in biology, but for biology students, when they first see this equation, they just shut down the fire. But this is not right, because right now in the current biology field we need more and more mathematics. So this really needs us to do the mathematics and deduction into our education system. Third, the computing program. Computational program to writing codes also become almost essential capability and skill for the current biological study. So this is kind of a very simple python program that some of my students were using in their research, and this basically has become almost a daily operation in manual biological projects. Also, logical reasoning. So this

is a kind of thing that is also happening. We need logical reasoning based on the results of quantitative analysis, rather than just description. But it's sort of the just a description. And also we need a quantitative point of view on biology questions.

This is another paper I use to teach in my courses to our undergraduate and graduate students about how we can use a quantitative way to analyze theories bacteria in the stochastic genome transfusion and actually carried out there's a new science behind it. This is from Sunny Xie in our university about 10 years ago. And they are still very useful nowadays for us to think about biological concept using a quantitative way and also in the stochastic event phenomena. And here is not just biology. There's also a chemistry as well as physics inside it. So in our courses, I think from this point of view, we should emphasize, for our biology education, on mathematics, physics, and computer science in the course design even for biology students. And also we should update the current course designs of mathematics, physics and other subjects, bringing in the statics, probability theory, linear algebra, stochastic process, and non-linear dynamics. Right now in our classes for our biological student, although they need to still take the mathematics, physics and chemistry courses in their first year or the second year in the undergraduate study, many of them are told by conventional mathematics and physics teachers who are still using most of the knowledge from something even a hundred years old, not many from the modern discovery in biology. So I think for more than biology, even more about some new concepts need to be used in life science, such as statistics, probability theory, as well as stochastic process and nonlinear dynamics. Also we should introduce more biological questions in our course design for the teacher who are teaching mathematics, physics, and chemistry as well as computer science, using examples from biology studies, rather than just staying with the comfortable examples that those teachers are doing. Also we should introduce more mathematical derivation and quantitative analysis in our current biology courses as

well.

About the second one, I want to emphasize that current modern science of biology is integration among sub-disciplines. So we start to try to use more full-spectrum from micro to macro scales in biology. Scientific questions are now at different levels from molecules to individuals and even populations. And we also now start in-vitro and in-vivo studies together. And also in biology, we used to have holism in microbiology, and now we use some more reductionism because we should now also convert these two together as well. And also we have a more comprehensive and broad application of various approaches.

So this is one example from colleagues from my school. They were using a single molecule technology to study a single molecule of anti-body receptor in the immune system. And actually they started the question from analyzing the human population all over the world to identify the genome difference among different humans, and then defined different humans may have different evolution, and then they analyzed it further and they narrowed it down to the molecule level to see why there is some difference for different locations of human may have different responses to certain autoimmune disease. And actually these are currently important to us to understand the human evolution as well. So you can see that now the biology study is already kind of forward scale following to the population and even to evolution and ecology as well. So this is really a new part of our biology.

This also needs our new concept in our biology courses. We need to have introduced concepts of evolution, species diversity and ecology in all courses, even when we are talking about molecular biology and talking about biochemistry. And also the latest progress and discoveries of molecular biology and cell biology need to be introduced in general biology and ecology courses, because these are also very important for people to understand from molecule level about the ecology. And also we need to try to diminish the boundaries among the subjects and majors,

because right now the field is really adding more and more co-work. We also need to explain the logics and the deduction process behind the major discoveries in biology, rather than just introduce, just tell the students "these are the discoveries that you need to memorize". We need to let them understand the history behind it, because this is actually how science is being formed. And also this will also help our students understand the logic, and they will learn the story. Actually as for myself, I still remember vividly when I was in the college, I took a course from a physics professor who was talking about the modern physics discoveries in the 20th century. And I got from there, just not only memorizing the final conclusion that they discovered, but also understanding how this big discovery was made about cosmic mechanics as well as relative theories. So this is very, very important.

The third one is right now the biology is really become a more cross-discipline with other fields. Actually if you see how the modern life science was established, especially in 19 40s to 1950s, many scientists actually are mostly from physics or chemistry. And research in this layer, the research is a major driving force for the modern life science. So for modern life science, we actually use a lot tools developed by physics, by computer scientists, even by some technic engineers that can help us to decide for very important biological questions. Modern life science is really driven by interdisciplinary research. On the other hand, life science is a very complicated phenomenon. I probably would say it is the most competent phenomenon in our universe. Right now, life science is also becoming a major driving force for many other disciplines, including physics, including chemistry, even for some mathematicians who are to see how we explain the very complicated biological phenomenon using mathematical theory and equations, trying to get up from new theories. So life science is also a major driving force for other disciplines. In life sciences, we are also recruiting professionals and expertise from other fields. Actually, in my school, in the school website of Tsinghua

University, we have about the 70 PIs and recruit those PIs, about 1/3 of them major in undergraduate studies who are not in biology. Some of them are from physics, some of them are from chemistry, some of them are even from mechanical engineering, and some of them are from computer science. So really life science is recruiting many other talents. Also in biology we now need to cultivate new concepts and new disciplines.

There are some new disciplines coming out. We are talking about the chemical biology. We are talking about physical biology. These are new frontiers developed in the life science field. Our biology students need to have skills to communicate across disciplines. So I always encourage my students to talk with their neighbors in their dorms, because Tsinghua, graduate students in the same department are not living together. Their neighbors may come from a totally different major, maybe from computer science, maybe from humanity. So I encourage my students to exchange ideas with them. This is very important. When I tried to deliver some messages to some non- biological students or scientists, I need to convey my idea to them, and I also need to understand what they are talking about, so that if we can have some common values, we can have some great exchanges between us about some new ideas in life science. So biology students need to have more skills to communicate across disciplines.

So this is just an example about CryoEM. So in the past few years, CryoEM has become a very powerful tool in the study of biology. So nowadays CryoEM is powerful not to solve our biological models in very fine details, so that we can even see the item that accumulates in the very complicated biological molecule. But this technology actually is developed throughout the years by many physicist, mathematician and computer scientist as well as engineers. So this is an example that revolutionized the CryoEM in the past five years. It is called a new detector. It comes from high energy particle physics scientists as well as some semi-

conductor engineers. It is a tool that allows us nowadays to take beautiful images of a CryoEM specimen, so that we can see our molecules —— these are just some viruses that we can see there how people use these detectors. All of these hardware and software behind it were not developed by biologists. They were all developed by physicist, by engineers, by computer scientists, by some mathematicians. So really the biology is inter-disciplinary nowadays. And the Nobel Prize was given to the CryoEM pioneers in 2017, and none of the three pioneers were trained as a biologist when they are in their undergraduate studies. Most of them are trained as a physicist or a chemist. Later on, they all made very impactful pioneer work to build this new technology, and nowadays all the biologists around the world all enjoy and also appreciate it. It is used in many important biological mechanisms and theories.

So I just asked my student to do some rough statistics about the biology-related Noble Prize laureates in the past 30 years from the Nobel Prize website. And I asked my students to see what all these Noble Prize laureates' undergraduate majors are in the past 30 years. Many of them went to college 40 or 50 or even earlier years ago. The statistics are quite interesting. About half of them started working in biology or medicine in undergraduate studies. Another half of them are from mathematics, physics, chemistry and some of them even have multi-majors in their undergraduate studies. Life science is really an interdisciplinary field, especially if you want to make a fundamental Nobel discovery. So I think in our biological education, we should tailor our biological courses for students from other disciplines. We should teach them with other major students with biology. We should tailor curriculum with courses from other field for biology students, and offer cross-disciplinary classes for both students in and out of biology, a platform for broad and in-depth cross-disciplinary communications and discussions. Actually now we do have teachers from non-biology background to teach our

biology students in mathematics or physics or chemistry, but we should encourage them not just teach the courses to our biology students, but also try to teach them in a way firstly used in their discipline, but also in another way also teach them using some biological context. This would require these teachers to communicate more with teachers in the school of life science or in the major of biology to discuss and design a curriculum, and teach the students in a more efficient way, and for a biology student to understand why we need to learn mathematics, why we need to learn physics, why we need to learn chemistry.

And certainly the fourth is biology is becoming more and more public impactful and also gain social attention. The first is an industrialization of modern technology, and biology has become more important nowadays. We have started to realize it, because we have public awareness on our health, food safety, environmental quality, etc. And also we need to have public education in life sciences. Requirements of social, humanitarian and legal ability are also biology-related professions as well.

So these are just a few examples. This is kind of about genetically modified crops. About a few years ago there has been major thing. Experiment was done by a group claiming that the GM really made a rat to have major tumor growth, and later there are some other people talking about starving the cancer cells. So if you search these terms, nowadays there are actually a lot of things related to our health and related to the food safety. They are very easy to become top news in the media, and many of the public are not aware of them very well. Many of them will easily get fooled, because they don’t have enough knowledge to judge whether the news is true. So really in our current biology for the social impact, biology should become a major component in liberal art education. And I also deliver this message to the president of our Tsinghua University, and we are trying to incorporate biology education in liberal art education in Tsinghua. We should also encourage

students with biology background to enter all different professional areas, including government leadership as well as lawmakers, and even media journalists. We should promote biological education to the general public. We should use new media and techniques for biology education. So to introduce a new media and tech into our biological education, certainly many of us have been aware of it, and we use online media, online technology, animation technology, and even some new technologies, such as virtual reality technologies. I just put two examples. This is a MOOC at the Tsinghua to introduce "general biology" courses. Also I myself have been involved in using a virtual reality technology, developing a new tool using a virtual reality micro-molecule. This is just kind of a software technology that has been developed to enable us to see in our virtue reality scene. We have already used it to educate our undergraduate as well as graduate students how to detect molecules to feel that you were inside the molecule. I hope that in the future we can adopt these into our courses, and certainly right now we are doing some pilot testing.

So at Tsinghua, even nowadays, we still see most of the regular courses for undergraduates are teacher-centered with few discussions and interactions, and we lack discoveries and breakthroughs in many courses design. So in Tsinghua, we have started to do some pilot programs. One is the Tsinghua Xuetang Life Science Program. This is more similar with the Zhiyuan College here. In this program, we put some student with high motivation and interest in research, so in this course, there's no specific course design for students, and the section of courses is not restricted to the program stipulated by the school. If the students in this program reduce their general course demands, so they have more flexibility. Each student is required to take four courses: "logic in life science research", "academic approaches", "scientific English writing" and "scientific research training". Scientific research training is about doing research in the lab, even when they are in

first year or second year undergraduate study. Students may request that the courses in the training program to be waived, if they feel that they don't need to do it. Also, we encourage students to select interdisciplinary courses as well. Also, our students in this program have a chance to go to international, including Michigan, Stanford, Toronto and Cambridge for summer internship and attend certain forums. We invited Nobel laureates to Tsinghua, and also have forums discussing with them. And also the students are encouraged to participate into real scientific research by joining open lab meetings and Journal Clubs. Also we are now designing new courses with innovation, like mathematics, physics, chemistry in biology, cancer biology, stem cell biology, chemical biology and modern biological technology. These courses are not only opened for undergraduate students, but also for graduate students.

We also have students who attended the International Genetically Engineered Machine (IGEM) competition. This is Tsinghua. We have this for almost decades now for undergraduate study to be involved and motivated in the study of biological courses as well as some research skills. And now we have started to have some joint programs. Here is the Harvard University and University of Cambridge Summer Internship, to invite international students to Tsinghua as well, to intern with our undergraduate students. We encourage our students to go to labs to do research, and some of the students even enter the lab in the first year in undergraduate study. When they graduate, some students have accumulated almost three or four years' research skills, and they are actually doing very well. So these are some of the papers and publications from our school of students with either first authorship or co-first authorship.

The last one is a program, not a new program any more, but we just had first graduate students who graduated about two years ago, so the program started about ten years ago. It's a new medical program which started at Tsinghua. It's

from undergraduate studies of the first year, and students will have an eight-year program. Among the eight-year ones, in the first three years, they will study at Tsinghua, and then spend two years overseas and some also do research in Australia. And in the last year they will come back to the clinical education to finalize their md degree. Through the program, students will have both the experience of medical education as well as a background of research. We hope to cultivate the next generation of physician scientists in China.

五、圆桌讨论（英文原文）

PANEL DISCUSSION

Let us invite all the speakers: Prof. Joaquim P. Nassar, Prof. Brian Coppola, Prof. Ramon A. Wyss, Prof. Hongwei Wang and Prof. Chong-Haur Sow. Today, we already have 8 series of lectures, which had covered multiple aspects about the cultivation of students, from the high education system in China and U.S., the development of multi-culture effectiveness to the education in the current information era, and the education system in France, Singapore and U.S.. We had a talk on the engineer education, about the difference between discovering and choosing of talents. We also discussed about higher education in life science. And my talk was about the curiosity-driven talent cultivation mode in Shanghai Jiao Tong University. We have already covered a lot on the talent cultivation, but several questions remain to be discussed. And now let us start the further discussion.

Junliang Zhang

The first question is how we can help our young faculty to help them prepare for cultivation and education toward young talents. Because we want our faculty to be of high standard both in teaching and talent cultivation. Here, we have several experts with significant experiences on talent cultivation, so we want to hear your voices and opinions. How can we help them? How can we prepare them? And

how important is it? As John Hopcroft mentioned this morning, we cannot use a 30-year-old campus and method to teach students born in the new era about how to embrace the future. I look forward to your opinions. Let us start from Prof. Joaquim P. Nassar.

Joaquim P. Nassar

Thank you. It is a quite broad question, so let us focus on the young teacher instead. I found it very interesting in the first point you just mentioned, which is what you get is what you measured.

So if you want reputations, you will get reputations. If you focus on the teaching duty, I have noticed that quite often, also in France, the teaching duty is counted in hours. So, young teachers maybe have 196 hours to teach a course per year as a result, and it does not encourage innovative ways of teaching. Because if we are just counting the face-to-face hours, then maybe it is a high number of hours, but they will need to spend additional time to design projects, work with students in small groups or meet individual caution requirements.

So very practically, we should think of credits from the point of view of the students. The credits, not being proportional to the hours, but being the measurement of workload of the students. If the teachers then instead of using credits to represent the hours the students need to spend, it gives them more freedom to organize the way they want to teach.

It has also been mentioned that group work is organized among students. Group work is a kind of measurement in research. The problem is that it is not

so common in teaching. Group work is an approach to teach something quite individually and give flexibility to add extra contents. It can be organized friendly by several teachers because it is an inter-disciplinary course. Group work is still not so common among current education system. And I think it is the duty of the university to create the framework to make these types of innovation possible.

Teachers might teach something quite individually, and giving flexibility to have some contents of some courses organized friendly by several teachers because it is an interdisciplinary course, or having projects designed by several teachers because you want the students to have interdisciplinary projects, (which) is still not so common.

Chorng-Haur Sow

OK. So, to share the experience in Singapore, in NUS (National University of Singapore), we have this organization called the Center for Developmental Teaching and Learning (CDTL). For all the young professors who have just joined the university, we require them to attend 3-week long courses at this center. This center organizes all kinds of courses to share with young professors about what are the dos and don’ts, what are the usual process or format. And on top of that, they will also invite very experienced professors who come and share experiences with the young professors so that they get up to speak about what is expected and how to prepare a good teaching module.

At the same time, at the end of this, younger professors are supposed to do a research project as in a project on teaching so he or she is supposed to try some interesting teaching approaches and then come and present these findings about

this positive and negative experiences on this teaching approach. So that is method No.1.

And method No.2 is that most of the heads of departments are required to assign a mentor to the assistant professor. So, the mentor serves as a more senior person in the department and can share knowledge on how to improve teaching. This mentorship goes beyond teaching so as to help them in terms of research aspect. This is what we are trying to do previously.

Brian Coppola

I have nearly the same answers with you, so I almost have nothing to say. Departments, for our answers to the questions, where departments really represent the most important home for the faculty, so that all the institutional support it performs is really departmental-environmental dependent. And the thing that I was going to say that you have said, so I agree with you quickly, is the things we do to support our young faculty's development into research should be exactly the same as all the start in all other occupations. And then includes mentorship, and then includes supporting values, guidance, then includes having a set of values that you are agreeing with. If I have to pick a characteristic of our department individuals that matters the most is that you agree about the important things. It almost does not matter sometimes what is agreed upon, it just matters we have a set of shared value. And so for example, to be agreed with our department, our newer large public university, therefore, at the introductory level, all of our courses have large universal students in multiple sections, and we would never leave a young faculty member alone. They are always part of the team and we have brought them majorities to share among young faculties that involve the expectations of the

classes, teaching strategies, and we want them to be successful in their teaching, the same way we want them to be successful in their research. And so the mentorship becomes very natural as a young faculty might be teaching me, and then we simply meet regularly.

We have an open discussions and presentations. We have guides that do not simply leave the person alone. If they failed and we will help. We are not always doing that, but since we began with that, we have these brand new assistant professors who have teaching courses at the end of their first semester, they are likely to continue teaching for thirty years and simply by not getting into trouble. So I think that the lesson No.1 is that the department is really their home, and that is the place where we need to get a set of shared value. No.2, they need to be open and transparent. No.3 there needs to be strong mentoring that does not make a distinct between the research mission and teaching mission. We simply want that person to be successful because we have invested an enormous amount of money in them. We do not want them to go away. In the following years, we want them to be successful.

Host: Junliang Zhang

Let me ask you this question in another way. You were the Vice President of KTH (Royal Institute of Technology), so probably the question will be how will you evaluate the performance of young faculty, include their research duty and teaching duty, and how shall we decide their salaries and promotions? Some might do a great job in teaching, but are very average in research, or the reverse situation. How should we balance teaching and research? What characters will help young faculty doing well? Please share your opinions.

Ramon A. Wyss

Maybe I am not the best person to answer, I mean, I am mainly in charge of the international relationship. There have been a few comments from our universities that intrinsically set the role of the university and that also account the faculty on three-fold, which includes research, new knowledge, and then teaching. Maybe teaching should come first. Number one is teaching, number two is research, and third is the interaction with society. And thus we also put a lot of emphasis at faculty's and university's needs to interact with society. It has to be so. Universities should not be a stand-alone union. And so, you should try to evaluate all three aspects in the career of a faculty going from a tenure-track, to become tenure. I think all three aspects are important. And we have learned a lot in particular putting much emphasis on education before all fine research emphasis which is also the easiest to measure, such as the citations or the numbers of papers. I think all universities can do much more education. At least I can acknowledge that I can do much more even though a lot of things have happened. And so the young faculty will need a better multiple portfolio. It is kind of compulsory, if you are a young faculty, you have to take courses in curricular development.

It is compulsory, you cannot get away from it. And students' evaluation makes every teacher now has this track record and portfolio evaluated. That is also where you have this sound self-reflection built. Now you reflect upon yourself as a teacher. And how you, yourself just have your development as the teacher. These aspects are very important. And I think that is really the key for universities sometimes. That is why I think that US is definitely better than at least what we are doing. I see their teachers balancing research and education, while ours sometimes

just concentrate on research only. This is scraping the system. I think it is really very important to put emphasis on all three aspects.

Host: Junliang Zhang

Thank you very much as well. Tsinghua University is very well-known university in China and in the world, and may have some different ideas on this topic. So may I ask what is your (Prof. Wang's) opinion toward this topic?

Hongwei Wang

I have to admit that, I have to say right now that all the top universities in China are doing up-side-down undergraduate education, including graduate education. Right now I think this is probably what is happening for China as a developing country. We are still trying to catch-up and I think most of the top universities, including Tsinghua and probably Shanghai Jiao Tong as well, we are emphasizing on doing our best now in research. So we are more emphasizing our faculty members on their research article. This is just kind of opposite to what John just mentioned this morning. I think what we will do in the future is to have more and more confidence on our researches and our academics, on generating papers for instance. But I think the most important thing for higher education is to nurture the new generation of scientists and to nurture the new leader for the world, so education is more important. So, I think it is what we should do and I totally agree with the previous few experts' views in education, mentioning that the evaluation is more important. I think this morning I learned two pictures from John Hopcroft that really fit our education, and how do we evaluate universities. And at the university level, the president would pick up how to evaluate our school departments and

deep in the school, as a gating of our school, I need to think about how to evaluate my faculty. So right now I think the most evaluation is still emphasizing on their research articles. Not too much, I think very little actually on the teaching and also education attribute or performance. This is something we should do together. I think at least at Tsinghua right now the university realizes it and starts to emphasize more and more on teaching and we are now going on the process of reforming our faculty promotion, especially junior faculty and promotion timing. We are right now reediting our policies and protocols so that we start to want to enforce more on their teaching performances and certainly also it is more important not to put more pressure on junior faculty on their common hours to teach, that is totally wrong and that is exactly becoming idiots actually. So, we should evaluate more on their quality of classes they teach, on how the students actually perform after the courses, rather than just counting on numbers of hours in class, and that s more important .

Junliang Zhang

Thanks for your opinion, and I believe Tsinghua do have some very unique idea and practice on this topic. This is the first question, and now let's start the second one. In China, we have two terms to name the development of talents: Juanyang and Sanyang（in Chinse, literally meaning rear in pens or sties vs. free range）, which means either we should provide each student the most effective education based on their own situation, and lay emphasis on every single special case, or we should select the talents of same specialties, and give them the best education. This morning, one of our speakers have another opinion. He said that this might be a way to select talents, but we can't ignore other students. The number of the rest of the students may be large, and the percentage of them

becoming future leaders may be low. But it is the very basic idea in education that we shouldn't ignore any student, and we shall offer them the same opportunity. Which approach shall we choose? I want to ask our speakers' advice on this dilemma.

Lisa Xuemin Xu

Juanyang and Sanyang means whether students in our honor program should be taught together in one program or spread out to different colleges.

Joaquim P. Nassar

It's really a difficult question. In my opinion, there's no consensus for your answer. If you have a renowned program, whether it's residential or not, you have to keep it going, and be sure that it stays open for different students of different talents and interests to choose various occupations in their lifetimes. In France during centuries, we have universities where there are some courses staying open for every student while some have an age barrier. And there is also highly-selective entrance examination. Some talents may pass the exam and have their selections of future path at the age of 20, while some take some time. Maybe they are not ready enough, maybe they have other interests, or they have a family history. They may need a few years of career before making their final decisions. These students are also of high potentials. I think the most important thing is that the system needs to arouse students' potential in different age stage, to be re-mentored and be boosted for their future career. Either concentrating in one field or dispersing into several, we need an open mode and atmosphere to ensure they have the very freedom and right to decide.

Chorng-Haur Sow

So again I share Singapore experiences. I think what Singapore is trying to do is also similar. We have multiple options for the students. We do have residential college, where we have a large number of students all stay in the same building, go through very nice format and full structured programs where they learn in very interesting, multi-disciplinary way. So that's one aspect. So I mentioned Special Programs in Science and I mention that there is another program called the University Scholars Program. Special Programs in Science combine all the sciences, University Scholars Program combines all the different disciplines you have, artists, scientists, lawyers all in the same building. So, we have that opportunities for them to come under one roof for the studies. But in addition to that we also have the specialty for the students who may need some late learning that they have not developed yet. So, they may not discover their talent and calling in the early years and then towards the later part of the year they become really good at what they're doing. So, we allow those students to still continue to grow. I think if universities offer multiple paths, multiple channels and then we can see which one is better for which student. My point is mainly something like that.

Brian Coppola

It altered for the whole time the answers. Well, let me emphasize two things. Number One, I do believe there is open solutions. However, the open solution has its responsibility of being the right kind of environment. If you have open solutions in the wrong environment, it is no good. It is also true its self-residential programs can be really good. But frankly I don't think it is because of the residential

program, it is because of their reputation. They will be couple places that good people go for self-identification. So graduate school in chemistry is one the most presentative program there is, only you can do chemistry in the lab and you cannot do it at home. 60% of the professors at the top 25 chemistry departments have either the PhD or the postdoc from Berkley. It is a very successful residential program and that is it isn't because they have an excellent program or because they have an excellent reputation, and people self-select to go there.

So, I think if you look at the most successful resolution program, look at Oxford, look at Cambridge, they are successful because of their reputation, because the good people are willing to go there, and they became reinforcements. So I think all parts of the grade it owns, open, close, residential, non-residential, all four formed parts are occupied, and the question is how unique the best of the situation you have. The tool, I do not think is ever the solution, and I don't think the answer is the residential program.

Ramon A. Wyss

Two comments: first one, from my own life, I actually started to get enrolled in the university very, very late, I was 28 to 29 years old. I worked in a workshop before. And also, I need to study for high school first. And I remember, the benefit being in Sweden, where the system was very open that you could enter a university when you are 30, depending on your credit and interests. I think, what most important is, there's a talent in every human being more and less. And there is the technique for identifying it really takes many times to make the wrong choices and then meet the right proper ones. What could make it possible is that the whole society allows to be open. And we discussed it can embrace any changes

in 100 years. I mean the technology is changing so rapidly, so we need to learn again, and we need to keep our doors open during life time. I think that is very important. You see this many times that you switch careers and do something else. And all of a sudden, it had a great impact on different subjects. So I think that's something, I would say something that I try to put on streamline and try to see other opportunities and offer something, for example admissions, certain admission by interviews, certain kind of admission by different people. And I think the more you mix, the more you create the environment that allows creativity to flourish.

Hongwei Wang

I might have two examples. One example is in Tsinghua, in our School of Life Science, we have a strict class and this strict class is more important, so our students are not immediately admitted to the class after they enter the university. Normally they need to apply in their year 2 or year 3 and there will be the interview to let them discuss. But they don't get into a specific residential or dormitory. They will still stay with their other classmates together. The effects of this class is they have more flexibility for their course selection, and they also have some kind of more discussion on their scientific topics and they are still very open, and at certain topics the students don't feel they are not targeted, or they don't feel very comfortable in the stuff they confront and even they did not perform good, they can come out as well. This is quite successful as we've seen. So I would favor a more open environment for students even they are already set for a certain kind of subjects, but not separate or isolate with other students.

In another example, we also have measurements for our environments for students targeted 8-year medical students program. And for these classes, students

are more get together with the designed program for physician scientists. They are largely motivated in that because they feel it they have their own goals and the class have the same goal, they want to be treated the same When they study, they study very hard and they work very hard and they also do their research quite good together and they are working on to keep this habit. So that is also an advantage for a specific goal. So, I really think we kind of like what we want our students to be in the future. If we have large specific goal like in our medical school, maybe that's okay. But if we want more open-minded students, I would be favorable for more open environment.

Junliang Zhang

So let's go to the next question. Since the undergraduate study only lasts four years, given it's such a short time, solidify our students' foundation or improve their ability on scientific research, which approach shall we weigh more? And how shall we balance these two factors as a faculty?

Hongwei Wang

I mean, just from my personal respective about the balance of research verses teaching, so me myself like teach very much because I feel that teaching is very stimulating detours for myself because just as I forgot who mentioned. Maybe as professors Sow mentioned that, teaching is by time, so actually I learn by teaching students. So, when I am teaching myself and teaching them and students also keep asking me new questions, and lead myself re-think about it and I learn it myself. So, I think it is very feedback from teaching myself. So, I like it very much. Every time when I prepare my teaching materials, I feel that I got some new ideas on

this and actually some of my research projects came from my teaching experience in the past few years. So, I think teaching and research are not contradicting from each other, these two are actually helping each other if we do them in the meanwhile.

I think for students it is the same, at least in biology, because biology itself is an experimental science and so once students do experiments, they are doing research. Actually most student's knowledge and logical, critical thinking got cultivated through doing research and at least in Tsinghua. We really encourage our undergraduate students to do research for that. Actually, we even motivate them to do search in lab by adding certain credit of their experimental courses.

Ramon A. Wyss

There's a few important aspects to consider. I can also give you something from my university. When I was enrolled, the teaching process is four years, but the average time for a student was six years and more, and the reason is that each professor was adding more and more subjects to their areas, the number of courses was increasing and the principal had very little control. I think first is that you need at least the dean or the school leader at the president level to control over what is supposed to be in the program. If I am supposed to be a student in chemical major or computer science area, I want the dean to have control or elsewise there could be too much to learn. Because if you leave that to the professors, all they will do is increase.

I remember for some biology major students, the physics was compulsory course, I was very upset because it was not made elective. Of course there was

science that you can catch up later on, you can study for later. The most important science we learn is math, the rest I mean you can always learn later. It is very important to have that foundation, but then you can just really make the student learn based on their self-interest. The key aspect is, so the student experiments themselves, to give them the choice to choose and have the central control of the program, which really assure students don't spend more time on compulsive than having time for greeting their own life outside, and learning in a different fashion.

Brian Coppola

For sure I also advocate what you just did, which is the balance. As I said earlier, one of the criticisms that the traditional Chinese system weighs too much overload on the course work in earlier years and there's no time to get involved in research. Sometimes they get involved and then are catching up so fast and have to compress in so few times. Whereas I think from the very beginning, it should be 25% of time on academic work, 25% of time on research work, 25% of time on the co-curriculum performance, peer structure and services. And then the last 25% of time by themselves, for they being able to figure something out, but have the balance all the way.

4 years is not a short amount of time, 4 yours is an enormous amount of time. These kids can really do lots of stuff which is more if given enough time so that after 4 years, they are better than they were after three years, better than after two years, better than after one year. So, there is time to develop and get better so that we are sure that senior students are better than freshmen students. The only way to do that is practicing and keep balance. The freshmen students will spend 35 hours a week in class and then every evening doing homework, there is no spare time,

and that's out of balance. But some time, the balance has been restored and achieve their new balance.

Chorng-Haur Sow

I totally agree that I think there can be a balance because in four years, there is actually a significant amount of time for us to try to cover all the aspects. In early years you can give the foundation training so that they have the basic knowledge. In the later years you can actually try to develop research aspect so they can become critical thinkers and then complex problem-solvers. So, when I teach the students, I always tell them: "Of course I'm very interested in teaching you the concepts of physics in order to gain a basic knowledge, foundation knowledge of how to become a physicist". Then I always tell the students I'm equally interested in training you to be a life-long learner. You know if I have trained you how to work on learning these you have not learned before, then that particular process is very precious. It was at the end the meaning of the process or experience that to pick up new knowledge in biomedical science, biophysical for instance, where you can learn it all by yourselves successfully. Even though they have not learned biophysics especially. So telling the student to try to learn the contents as well as the process, the method to find things, the method to solve problem, I think that is very well relevant to the life-long learning.

Joaquim P. Nassar

Thank you. I think I may have a little bit disagreement in this debate. Actually, in France we are apparently not able to comply with your thoughts. You see, today there are a lot of skills to master if you want to satisfy the requirements of an

engineer: an international sight, internship in domestic and international companies and experience in laboratories. If you add all the time together, four years are still not enough.

Let’s pay attention to current technologies’ sophistication of objects in daily life. When I was a kid, it was sensational to imagine the existence of cell phones. The development of circuits has no relationship with what I knew at the age of a child. In my opinion, we are just paying more time to understand the basis. If you say “OK, I don’t know and I don’t need to know any more about the physics principle of the system. I just need to be able to use it”, you are mainly live in a magic world. From an international context, sometimes you need to go back to the current breakthrough’s technology basis. You cannot just rely on building the superstructure of the technology, and buy ideas from others. In some case, we still want to connect to the basic physics.

I like the idea we talked about this morning that we say we should design our life with a time scale of 100 years. And it’s not that we are under the same age of equal and there’s 80 years after under graduation, so the whole life is expanded. If you see a woman from the medieval age, who could marry at 14 or 15, and now we wouldn’t consider it proper. So actually, our whole-time scale of the life is expanded, and we just also need more time to study. And it shouldn’t be necessary in one piece, as we notice that some students at the age of 18 might need to do something else. Maybe they need to work for a few years, and later they’ll come back to the campus. And in the end, we believe that they still need more than 4 years to have all the useful knowledge to be studied.

Ramon A. Wyss

I don't think it matters whether you say three years or four years or five years. I think it doesn't really affect you, in this time you are given, make sure there's progression and time for the students, and then of course, in five years, you should learn more than three years, but it depends on the industry, the society, and of course you do the master or PhD. Maybe some industries have more PhDs.. I think that is possible and shifty. Three weeks ago, I was in Qingdao, and I met a few students and one of the students has been on campus for three years, staying inside. And that was his first time in Qingdao outside the campus. He never visited Qingdao before. I think that's not good, because you need to have time to go around, go to the cinema, and reflect on your own, I think this is very important, this kind of social interaction, and that is a lot of learning built in this non-education.

Junliang Zhang

I think we have several different answers toward this topic. And I think at least for our students, all knowledge weighs the same. The designation of education system, whether three years, four years or five years, is very important. If the time is longer, the focus of attention and learning must be given more. Sometimes, we need to strike a balance between research program and study program. We have prepared and shared a lot on how to make students build a solid foundation, and meanwhile we also hope their scientific research skill got improved a lot. There are a lot of questions remained to be discussed, but since our time is limited, maybe we should let the audience ask their questions.

Audience A (Lei Zhang)

My name is Lei Zhang, from the Office of Strategic Planning in Shanghai Jiao Tong University. My question is about ranking. Prof. Coppola's opinion is that we should stop ranking immediately, and thinking of the long term reputation of the institution. So I want to ask the other professors whether you agree or disagree with his opinion, and your opinions about ranking's role and position in building a world-class university. And how to build a world-class university or institution?

Ramon A. Wyss

A great question. First of all, I think the answer depends on what we try to get out of the ranking. I think it will change or be mistaken. But it's a good system for selection, just make sure to have 20% interviewed in other ways. I don't know but, first, it is always a challenge of the corruption issue. You want to be calculating. The issue is that the students are inside the university, that is the question (of whether) should you rank them or is it necessary. You want to be very careful, some students are very fond of mathematics, but don't like chemistry. Every student finds their own subjects. I think the students have passion to study what they like to study. And that is a very strong driving force. Ranking is counter-productive. I would say this choice is a bit of artificial. That will be my simple answer.

Brian Coppola

I think the only thing I will say is that my statement was very strongly followed what he said, and was very strongly directed to the university level, if you still want to use Gao Kao, which is still used obviously. What I didn't say is

because I was being too polite. I didn't seem like being polite, but I was being polite at least in this moment. We don't care. We don't use that information. You want to use that information, when you rank your students are you using that information? No, that is somehow for my benefit. I tell you, I don't care, we don't use it, end of story. We have gone so completely over to grade-based-evaluation, we have to have a baseline level for GRE, as well as baseline level for TOEFL. And then we ignore, we have no interest in what so ever in the class writing. So, who it is for? If you are not doing it for you, and I do not use it. Why we have it?

Joaquim P. Nassar

Yes. And I think knows is better than selection, which seems to be cheaper. As the selection process can be totally relied on you.

Let me tell you a small story first. A few years ago, when I was working at the Poly Technique, which is known in France as No.1 in engineering. In 1975, there was a big debate: should we admit female students in the 1970s? By then, the university entrance examination was open to females for the first time. A girl won the first place the test, so there was no debate anymore. The examination brought the female to the system.

So sometimes ranking can bring some measurements of talents. And of course, if you have many more competitors than seats, any criteria can be disputable. And apparently, if we cancel the entrance examination, university will have another ranking, which is the ranking of money from our parents. This fundamentally debate about misconduct can also find among U.S. universities.

I was saying that we can rely on more systems, and what has been experimented in France is to mix the solutions first and then choose the best combination. It could be the mixture of competitive examinations, individual education background and standard, and the students' personal achievement. But even this kind of selection can be biased.

What has been experimented in France is the mix of solutions for combination, which is the least biased? Example. So part of the candidates admitted through competitive exams as rankings, part of candidates admitted based on individual application, usually measure candidates, which can prove and show more achievements.

Hongwei Wang

Actually, I think sometimes we have to admit in kind that in China, we put the equal mark between ranking and reputation. Actually, these two are not equal. I know ranking high does not mean there is a high reputation. But I think actually different universities just have their different characteristics, just like personality. So, I will say when I went to college, I think there was no ranking and I just chose the one I like it. Doesn't mean Peking university is not good, just because I like Tsinghua and I entered Tsinghua and in Tsinghua I was happy. And here the same thing happens in Shanghai, between Fudan and Shanghai Jiao Tong. I will not say who is the best, because these two universities have their own university style.

So, I think the reputations is more important rather than the ranking. And the same thing from the biological point of view, the world is so prosperous, and so interesting because we have so many species. We cannot rank the species who is

the most successful one. Sometimes, as human beings, we want to say that we are most advanced life form on the Earth. But sometimes, if you really think about it, we are not the most successful species. The most successful species on the Earth should be the micros. They are the most successful ones. So, really different universities have different personalities and characteristics, so I will not favor for ranking them at all.

Host: Junliang Zhang

I think we already have enough discussion on this topic. And we should use ranking very carefully, and maybe we should use some other competitive methods. I think there's still time for another short question. Any questions?

Audience B (Weiliang Xia)

My question is, imagine a hundred years from now, we also have expertise from different fields sitting together. How do you think today's discussion will affect the world after a hundred years?

Ramon A. Wyss

First of all, I would not travel here. It will be some virtual presence; I would be in Stockholm and you would see me here. Hehe, number one. And you see how there are schools where you have no teachers and no exams. In France in computing or something you started, it still has a long way to go. But I think maybe, much of it all depends on the universities. Because students very well had education when they go to high school and so on, but I think we will also see a

lot of very different ways on how we learn and teach, which is very important. Because what we encourage many times is peer learning in-between the students and where you call coaching. At the end, you have to learn by yourself, nobody can put it in your brain. So, all we can learn is to learn ourselves, and there is less work you need to do. I think that's something going to become much more.

Hongwei Wang

I remembered a story my grandfather told me. He was in a private school at that time, which we called Sishu (私 塾). If he did not work very hard, and got beaten in his hands. So, the education at that time was like that. I would like to say the education really changed a lot. The system and also the value really change a lot in the hundred years. So, a hundred years later, we really do not know what will happen. Maybe there will be no school available any more, maybe the technology development of neuroscience or brain connection to the Internet, whatever it is, maybe life will be totally different from our days. But I think the soul will still exist and the human beings, because our culture and evolutions, and all our knowledge passed to the next generation will not change. That is pretty much what I want to say.

Chorng-Haur Sow

I mean, this is a difficult question to answer. I guess my personal opinion is that the education system will evolve with the demands of the society, so we are going next 10, 20 years old artificial intelligence-particular generation? After the Internet come to an existence, some jobs are going to become substitutable. So, what do we train our students for? Some of jobs will no longer be required so we don't provide

these trainings any more. And with the arrival of and development of these AI, data science, perhaps now we need to train the students with different sets of skills to be the manager of computers, to be the manager of robots. That's actually 10, 20 years I think may have already, 100 years are hard to know.

Brian Coppola

So, I will answer it in a different way. Right, I answer it another bit. The purpose of today's symposium is to answer the question about the need and interest to cultivate hundreds of people. That's going to be exactly the same a hundred years from now, two hundred years from now, and three hundred years from now. The tools will look different, the procedures will look different, and what we try to accomplish will be different, but the need to cultivate candidate individuals start off as babies. They have to come up to speed with incredible answers that you made. It is true that over these one hundred or two hundred years, it still takes about ten years to turn a high school graduate into a functional professional. The size of the box has not changed, but we do insight that states is actually quite dramatically different than it was 100 years ago. And I think it will continue to become more efficient, creative, but I don't think the basic need to cultivate talents will change.

Joaquim P. Nassar

There is a saying that prediction is difficult, especially if it's about the future, because anything we say might be wrong. I think one of the trends in China is the ability to define an area within which an experiment is carried out. The special economic zones designed by Xiaoping Deng are very famous in the western world as well. I think that the Zhiyuan College is such kind of a special zone, as Shanghai

Jiao Tong University may not be easy to launch campus-wide experimental changes. But in fact, if you open a zone, you are trying new things. And that is the current trend. Like what Prof. Hopcroft said this morning, you don't need to assign a big great fund for the university. A couple of competent professors within this department are enough to illustrate new concept, new approaches, and generalize their successes. In my university, there's a couple of professors who also have interesting ideas. If they are given the space to do experiment, this platform could have a real impact.

Brian Coppola

There is one other thing that I want to say and I think everybody in this room needs to think about it. There will be a difference some hundred years from now and I think the contribution from this country will be much more significant than it has been because one of the things that it has impressed the hell of me. One of the reasons that I love to come to China, interact with China, and learn about it is your own history. I think you should wake up every day and remember that 40 years ago, 40 years ago you re-invented higher education, in the class of 78, 40 years ago, in one generation, people have re-invented education. And that generation still has not passed or stopped. Lin was in the class of 78, and he is still around and he is still active. Can you image being in the first class, join a freshman plans where there was no sub-course, no junior and the professor will be going to wait for 33 years and everything had to be re-invented. When I started coming here in 2001, chemistry departments were trying to get their first paper in the Journal of America Chemical Society. Now everything has changed, and the world in general does appreciate is the great progress that has been here. And so I see one thing that is 200 years from now is going to be that Chinese leadership in whatever it is going

on.

Host: Junliang Zhang

Actually, I cannot agree less with Prof. Wang on this topic. In the future, we will still have engineers to be responsible for engineering issues and scientists for scientific issues. And in the future, our education will still be the key to the cultivation of talents. And at least we will prepare our students to have a future view, a global view and an inter-culture view, so that they can better cultivate the next generation. In the next a hundred years, they will help us fulfil our duties. And if we fail to do so, then it will be a combat doomed to be lost. Though I think there's still a lot to be discussed, but out time is limited, and let's end this section.