Implement a Pipeline (Youth-Undergrads-Professionals) to Promote STEAM

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Key R&D Discoveries for Implementing Mentor-Assisted Enrichment Projects

Over 16 semesters of R&D (1978-1985), more than 300 Undergrads served as mentors for more than 1,000 Youth in grades 4-12 while implementing a Mentor-Assisted Enrichment Project [MAEP] over 10 weeks.

I discovered key factors (incentives, structures, processes, training, roles, responsibilities) that are essential for making multi-media Mentor-Assisted Enrichment Projects [MAEPs] beneficial for all participants:

- for ***undergrads*** who share their expertise as mentors with small groups of interested proteges and earn course credit for providing effective Group Mentoring,
- for ***youth*** in grades 4-12 who want to carry out and complete a MAEP and create a Multi-Media Presentation (MMPs) that illustrates what they did and learned,
- for ***faculty*** who provide the mentors and can later use the MMPs to enhance their own instruction,
- for ***teachers*** who provide the proteges and can use the MMPs as the basis for "lesson plans" they cannot create themselves,
- for ***professionals*** who demonstrate real-world applications of STEAM concepts,
- for ***parents*** who appreciate the multi-media enrichment experiences their children engage in outside the classroom,
- for participating ***universities, colleges, schools, and corporations*** whose reputations are enhanced from supporting Cooperative/Collaborative Learning through an evidence-based approach that integrates Teaching/Learning.

Some additional key R&D discoveries include these:

- undergrad-mentors earning course credit is the best "quality control" for ensuring effective mentoring is provided,
- youth can identify better with undergrads than older mentors and thus become more motivated to take STEAM-related courses needed to become STEAM undergrads,
- both Didactic Instruction and Open Inquiry are necessary to enhance STEAM education, and undergrads can be trained to provide both,
- undergrad-mentors ensure each protege "learns about" STEAM concepts and mentors also involve STEAM professionals to help proteges "learn how" applications are occurring in real world settings,
- mentors need training to employ different Mentoring Styles and behaviors, so proteges will be receptive and will utilize assistance that is provided,
- proteges must "buy into" the mentor's Mentoring Action Plan so they will carry it out to completion,
- my approach creates a STEAM Pipeline of youth who want to become STEAM majors, who graduate as more competent STEAM professionals (including teachers of STEAM subjects).

A fundamentally important R&D discovery is that neither (a) simple "Announcements" to engage in group mentoring nor (b) partially-planned "Initiatives" can produce the intended Multiple Benefits for all participants listed below.

In contrast, a carefully planned and properly implemented "Mentoring Program" will produce these and other Benefits as intended outcomes and results.

In a true "Program" all essential components are defined, designed, aligned and then delivered to produce intended outcomes: we first identified the Benefits (outcomes, results) we intended to produce, and then thoughtfully planned and structured the Processes needed to produce them.

Key Benefits from Mentor-Assisted Enrichment Projects

Before describing Mentor-Assisted Enrichment Projects, which are carried out by undergrad-mentors (for course credit) with proteges in Grades 4-12, it is appropriate to focus on some of the Multiple Benefits that MAEPs produce when properly planned and implemented.

Student-proteges benefit in multiple ways, such as:

- Learn how to *plan* and *carry out* a project – and create and give a Multi-Media *Presentation* of what was done and learned.
- Learn to *connect* "knowing about" STEAM concepts with "knowing how" they are applied in real world situations.
- Utilize *higher-level thinking skills* in each project (based on Bloom's Cognitive Taxonomy).
- Learn how to collaborate and take turns leading and following (being *team members*) within the project group.
- Learn how to interview and job shadow STEAM professionals to "learn how" real world applications occur, and to learn about interesting STEAM occupations.
- Learn how to give a public presentation to an audience to learn speaking skills and confidence.
- Complete something they start to gain a feeling of accomplishment (*parents* especially appreciate this).

Undergraduate-mentors benefit in multiple ways, such as:

- Learn to use 4 Mentoring Styles to *equip* and *empower* proteges.
- Learn *project management competencies* by planning, carrying out, completing and presenting a MAEP with a group of proteges.
- Learn how to get proteges to see the Project as "theirs" so they show up, prepared for scheduled activities.
- Learn how to make MAEP activities so engaging that proteges will complete and present "their" MAEP.
- Learn how to utilize STEAM professionals (too busy to be primary mentors) to motivate interest in STEAM occupations.
- Learn how to get proteges ready to give a Multi-Media Presentation of their completed MAEP.

Faculty benefit in multiple ways, such as:

- Learn how to structure a course assignment so all requirements will be met.
- Learn how to make course content more practically relevant.
- Get significantly higher course evaluations from mentors vs. other students.
- Can use the Multi-Media Presentations of completed MAEPs to enhance their own instruction.

Teachers benefit in multiple ways, such as:

- Learn how to work more cooperatively with faculty and mentors.
- Can use the Multi-Media Presentations of completed MAEPs to enhance their own instruction.
- Class size will decrease while proteges are meeting with mentors, so teachers have time to assist other students.
- *Parents* appreciate teachers more because their children benefit in multiple ways from completing a MAEP.

Schools and universities/colleges benefit in multiple ways, such as:

- Learn how to work together more cooperatively – on projects and associated research.
- Because many MAEP activities occur on university/college campuses, this recruits proteges to attend there.
- Enhance curriculum and instruction by using the Multi-Media Presentations of completed MAEPs.

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Why is Collaboration Necessary to Create a STEAM Pipeline?

To create a STEAM Pipeline (Youth–Undergrads–Professionals) that implements Mentor-Assisted Enrichment Projects rectifies *qualitative shortcomings* (e.g., lack of needed competencies) and *quantitative shortages* associated with each group below:

- Assist more Youth to become college-and-career ready (for STEAM majors and careers).
- Ensure Undergrads become competent STEAM Professionals.
- More STEAM professionals solve challenging problems that benefit society.

With other approaches, only two of these three groups are involved in a STEAM Initiative, such as when undergrads assist youth with Robotics or Rocketry in After School Programs. Or, when professionals mentor undergrads or youth. In contrast to such narrowly focused approaches, my concept of structured Mentor-Assisted Enrichment Projects:

- involves and links all three groups to create a *STEAM Pipeline* of Youth, who become STEAM Majors, who become competent STEAM Professionals,
- this rectifies quantitative shortages and qualitative shortcomings that have caused the USA to fall behind other nations in the quantity and quality of individuals in these three groups,
- both formal and informal learning are involved instead of favoring one over the other for ideological reasons,
- mentoring teams utilize multi-media learning resources that engage all learning modalities,
- mentors provide Didactic Instruction to ensure learning of "basic concepts" and facilitate Open Inquiry to solve problems and generate new knowledge.

Didactic Instruction involves reading, listening and seeing what is presented, so that existing knowledge is imparted to learners and does not have to be rediscovered via trial-and-error over time. Unfortunately, 10 to 50% of what is presented is often forgotten because such learning is often passive.

Open Inquiry requires engagement in active learning-by-doing that is better remembered, but is often not fully understood without some instruction. Both learning methods are needed, by most learners, most of the time, according to a seven-year study at Johns Hopkins University forty years ago (Coleman et al. 1973).

How do Mentor-Assisted Enrichment Projects help younger proteges connect "learning about" STEAM concepts with "learning how" they are applied in the real world? Here is one example: A small team of proteges wanted to learn about the relationship between architectural design and construction of buildings. Their mentor took them to view and take photos of all the major buildings in Vancouver, Canada that Arthur Erikson had designed – and then helped the proteges formulate good questions to ask him. Such as: "What design and construction problems had to be solved when you decided to let large trees grow through the roof of the underground library at the University of British Columbia?" "What challenges had to be resolved when you designed Simon Fraser University as a single construction to sit on top of Burnaby Mountain?" (Erikson won the 1986 Gold Medal from the American Institute of Architects. He was pleased to spend time with these well-prepared youth, who wanted to become architects – like him.)

This involvement of youth + undergrads + professionals is important because it enables young proteges to overcome their fear of science and math courses, on the one hand, while exposing them to the possibilities and realities of STEAM careers, on the other hand. Young proteges easily identify with undergrads (because there is not a large "age gap") and talk candidly with them, and they learn about "best-fit" careers from busy professionals, so they can pursue the right career for them.

What is a Mentor-Assisted Enrichment Project?

Mentors are undergrads, who earn course credit for providing effective mentoring, based on each mentor's existing expertise. Undergrad-*mentors* provide the "missing link" between youth and professionals as well as the "bridge" that connects youth with professionals, who are too busy to be full-time mentors, but can contribute to a Mentor-Assisted Enrichment Project when appropriate. Because the "age gap" is small, proteges can easily

identify with, talk candidly with, and emulate undergrad-*mentors*, who have achieved success dealing with the same challenges proteges are encountering.

Undergrad-mentors ***assist*** small groups of interested youth (proteges) to plan, carry out, complete and present each MAEP, which is based on a Mentoring Action Plan that mentors create to serve as a structured "roadmap." Mentors *assist* proteges to have input into the Mentoring Action Plan, so they view it as "theirs" and will attend scheduled meetings prepared for each activity, so they complete the MAP.

Each MAEP provides ***enrichment*** that cannot be provided in the regular curriculum via typical instruction, such as job shadowing and interviews with professionals to learn how real world applications of STEAM concepts are being used to solve real world challenges, and creating and giving Multi-Media Presentations that illustrate what was done and learned.

Carrying out all phases of a Mentoring Action Plan requires mentors to function as a manager of a ***project***, which has a planned beginning, middle execution, and final completion and presentation – so each *project* stays on schedule and on budget. Proteges learn to collaborate as team members on "their" project.

Maximizing Learning Using STEAM Education Kits and Mentoring Action Plans

Undergrads can be trained to use *STEAM Education Kits* properly to maximize learning for individuals in their small group of proteges, and to produce benefits such as these:

- Students have 64% improvement in Math Scores and 128% increase in Technology Scores.
- Promote project-based, student-driven, STEAM directed activities for K- 12 students.
- Builds Student Self Esteem
- Introduces Real World Applications of Math and Science
- Promotes 21st Century Skills: Critical thinking, Communication, Collaboration, Creativity.

These Kits provide a focus for learning the 4 C's mentioned above: Mentors are trained to teach proteges how to engage in **Collaborative Learning** by learning how to:

- work collaboratively/cooperatively on a team,
- take turns being the leader and follower,
- listen to each other's ideas and try ideas that seem promising of a problem solution,
- complete a task they start by solving the problem, and
- give a presentation where they describe what they did and learned. Proteges learn propositional thinking (what if I do this or that, what will be the consequence?) as they solve problems.

Why must mentors create a **Mentoring Action Plan** in order to share their expertise effectively? I found that 29 of 31 proteges reported (Gray, 1982) that they must complete all agreed-upon activities in the Mentoring Action Plan in order to view the Mentor-Assisted Enrichment Project [MAEP] as worthwhile. This finding is highly significant statistically ($p < .0000$). Parents of these proteges were especially pleased that their children had accomplished something worthwhile, which became especially evident when they saw their children's Multi-media Presentations that illustrated what was done and learned.

In addition, when Mentoring Action Plan activities take place on campus, this exposes youth to professors and facilities they did not know about before. This entices them to consider enrolling at these institutions. When activities take place where professionals work, this exposes proteges and mentors to real world applications and to potential employers, who are looking for "new hires" who know how to work together collaboratively on teams that perform well to produce desired outcomes.

Can proteges carry out, complete and present a Self-Directed Enrichment Project [SDEP] entirely on their own, after carrying out a Mentor-Assisted Enrichment Project [MAEP]? I discovered (Gray, 1982) that proteges want to carry out a SDEP, and tried to, but there were significant differences favoring MAEPs. Such as:

- more MAEPs were completed and were better presented,
- MAEPs were better planned and involved more multi-media resources in the community,
- MAEPs enabled proteges to learn how to take more responsibility for doing an enrichment project,
- proteges put more effort into MAEPs, and were more satisfied with this type of project.

Conclusions

Undergrad-mentors are the "bridge" that connects Youth with Professionals, who are too busy to be full-time mentors, but can plug in to a Mentor-Assisted Enrichment Project when appropriate. Earning course credit as an Undergrad-mentor provides "quality control" to ensure mentoring effectiveness occurs in these specific ways:

- connecting "learning about" STEAM concepts with "learning how" they are being applied in the real world by professionals;
- properly utilizing STEM Education kits to maximize learning for individuals;
- employing both didactic instruction and open inquiry because both teaching/learning methods are needed most of the time by most learners to learn most things.

Mentor-Assisted Enrichment Projects, based on each mentor's expertise, provide a structure for planning, carrying out, completing and presenting what was done and learned. The Mentoring Action Plan provides a "roadmap" for varied activities to be done, so everyone comes prepared to scheduled meetings. These R&D discoveries are essential components for creating a *complete* STEAM Pipeline of Youth, who become STEAM Majors, who become STEAM Professionals – to rectify quantitative shortages in each group as well as qualitative shortcomings (e.g., lack of needed competencies).

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