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Developing Students' Understanding of Global Issues through Lean Manufacturing

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Abstract

While traditional international exchange programs provide valuable experience for engineering students, they are neither within reach nor practical for all students. An innovative course was developed and executed Spring 2007 to provide engineering students with an intense international experience. This course is aimed at strengthening ABET outcome item (h) [the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context]. Additionally, the course provides students the opportunity to practice contemporary, industry-relevant skills by exploring lean manufacturing, including tools, philosophies, and current literature. In the first offering of the course, fifteen students participated on kaizen teams at companies in the United Kingdom and the United States. Survey results of student participants indicate that the experience increased students' understanding of global issues and lean manufacturing. Feedback from industrial partners also showed that this was an effective exercise for developing students' understanding of these issues. This paper describes the creation of this course, including the assessment data that provided the impetus for its inception. Course content, structure, and activities are detailed. Survey results are examined. Long term impact expectations and assessment plans are described.

Keywords

Global competency, International exchange, Kaizen, Lean manufacturing

Disciplines

Industrial Engineering | International and Comparative Education | Manufacturing

Comments

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Developing Students' Understanding of Global Issues through Lean Manufacturing

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Abstract – While traditional international exchange programs provide valuable experience for engineering students, they are neither within reach nor practical for all students. An innovative course was developed and executed Spring 2007 to provide engineering students with an intense international experience. This course is aimed at strengthening ABET outcome item (h) [the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context]. Additionally, the course provides students the opportunity to practice contemporary, industry-relevant skills by exploring lean manufacturing, including tools, philosophies, and current literature. In the first offering of the course, fifteen students participated on kaizen teams at companies in the United Kingdom and the United States. Survey results of student participants indicate that the experience increased students' understanding of global issues and lean manufacturing. Feedback from industrial partners also showed that this was an effective exercise for developing students' understanding of these issues. This paper describes the creation of this course, including the assessment data that provided the impetus for its inception. Course content, structure, and activities are detailed. Survey results are examined. Long term impact expectations and assessment plans are described.

Index Terms – Global competency, International exchange, Kaizen, Lean manufacturing

INTRODUCTION

Since 2000, ABET has stressed the importance of engineering students developing their professional skills along with their technical skills. Outcome item (h) [the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context] [1] has been recognized and categorized as one of these professional skills [2]. Shuman et al. stress that these professional skills have always been important, but are now of critical concern for various reasons, including globalization [2]. Downey et al. ask and answer the question, “What does it mean for engineers to be globally competent?” [3]. They caution that “...one key feature of a globalizing world is that it is increasingly difficult and, indeed, problematic to characterize people as

members of different cultures” [3]. This challenge exists because people and businesses are so much more mobile than they used to be, significantly reducing the population who subscribe to a single country's cultural identity as a function of national terms [3]. Recognizing this, then, makes it even more prudent for engineering students to have numerous and significant interactions with people whose ways of defining and solving problems are different from their own [3]. Achievement of global competency is impacted by these interactions, regardless of how the differences map across or within countries [3]. Student are said to be globally competent if they have the ability to work effectively with people who define problems differently from themselves [3].

Not coincidentally, at the same time that ABET and the U.S. engineering education community have been supporting and driving increased awareness of global competency, industry has recognized the same priority. For example, today's global supply chains require understanding of global context and culture so that businesses can be as effective and profitable as possible. Extensive analysis and research is being conducted by many stakeholders today, as evidenced by articles such as those by Hochman et al. and Cohen et al. [4] [5].

While business and academia have been clear on the importance of global competency for the past several years, there has also been another revolution with respect to culture in a business setting; however, this transformation has been in process for decades. The Toyota Production System (TPS), which has its own roots in the teachings of many U.S. business pioneers such as Ford, Juran, and Deming [6], was conceptualized by Taiichi Ohno in the 1950's. One of the founding principles of TPS, or Lean Manufacturing as it is often called in the U.S. in current business practice, is the value of people in an organization and the creation of a culture of continuous improvement [6].

The question of how to provide experience to engineering students which addresses culture in both professional and technical context is a challenging one. Current literature supports that international experiences are a tremendous way for engineering students to learn to appreciate and work with other cultures [3]. However, traditional study abroad is not practical for all students for various reasons. For some, it is prohibitively expensive. For others, their engineering programs are not as conducive to international study. Most recent data (2006) shows that less

than 3% of U.S. engineering students seek international enrollments, and this percentage has remained essentially unchanged since 1997 [7].

The convergence of these four key factors - ABET emphasis, current global business models, the prevalence of lean manufacturing philosophy, and the recent emphasis on students having international experiences - is what triggered the creation of a new course at Iowa State University (ISU). This course was designed to address these four factors as well as input from the department's Industrial Advisory Board, as is explained in the next section.

IMPETUS FOR COURSE

Since before 2000, ISU's Industrial and Manufacturing Systems Engineering (IMSE) department has been assessing and addressing sixteen different outcome items; the first eleven are mandated by ABET, and the last five are additionally required by the department [9]. These outcome items include the following:

- a. apply mathematics, science and engineering principles
- b. design and conduct experiments and interpret data
- c. design a system, component, or process to meet desired need
- d. function on multidisciplinary teams
- e. identify, formulate, and solve engineering problems
- f. understanding of professional and ethical responsibility
- g. communicate effectively
- h. know social, economic, and international implications of engineering solutions, and understand their impacts on people and communities
- i. recognize the need for and to engage in life-long learning
- j. know international and diversity perspectives, and understand contemporary issues of industrial engineering
- k. use the techniques, skills, and modern engineering tools necessary for engineering practice
- l. be able to design, analyze, implement, and manage effective production and service systems
- m. be able to integrate the engineering and business processes of an organization
- n. be able to integrate processes involving people, material, equipment, information, and energy
- o. know the relationships among local units of a global enterprise, and understand local regulatory and cultural effects on the global enterprise
- p. be able to provide leadership in multi-functional teams

As reported by Potter and Min in 2005, assessments include both direct measures (rubrics) and indirect measures (surveys) [8]. The rubric for outcome item (h) has been shown and discussed in detail, firstly at the 2005 ASEE North Midwest Conference [8]. This rubric is evaluated by the course instructors at the end of each semester, and is used to assess broad education, global participation, and understanding impact on three different levels (exemplary, acceptable, and poor) [10]. Since 2004, outcome item (h)

has been assessed in the capstone design course six times. While the data from the Fall 2004 semester is an anomaly because of some initial process problems (as reported previously) [10], the data remaining after ignoring Fall 2004 still provides sufficient support for the need for concentrated improvement in the area of students understanding the impact of engineering solutions in a global context.

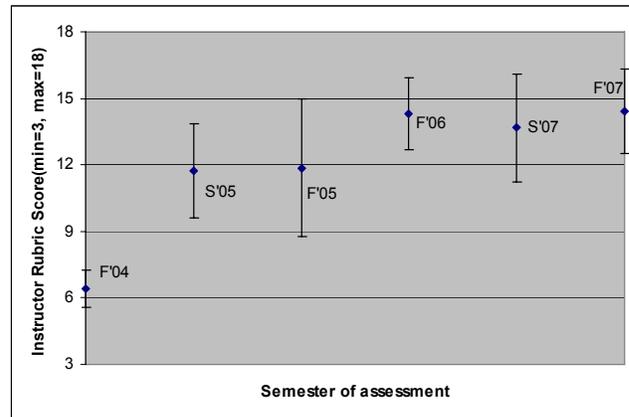


FIGURE 1
AVERAGE RUBRIC SCORES IN CAPSTONE DESIGN COURSE OVER SIX SEMESTER FOR OUTCOME ITEM (H) AS ASSESSED BY INSTRUCTOR

Likewise, survey data has been collected from graduating seniors from the IMSE department regarding their self-reported abilities for the sixteen departmental outcome items. Results of this data for outcome item (h) show that averages have generally converged around a score of 4.0 (Max-best=5, Min-worst=1). These results again indicate that while students believe their skills in this area are good, there is still room for improvement.

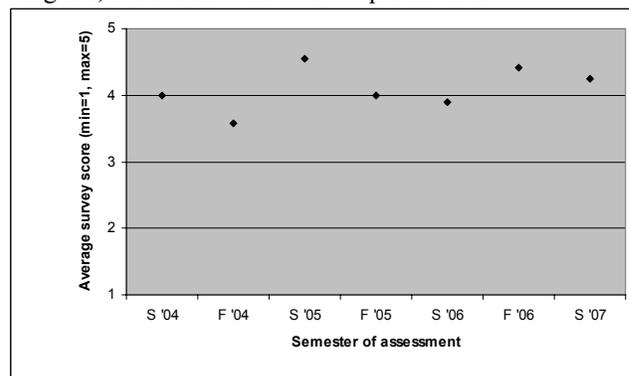


FIGURE 2
AVERAGE GRADUATING SENIOR SURVEY SCORES FOR OUTCOME ITEM (H) OVER SEVEN SEMESTERS.

In 2005, Potter and Min reported their assessment findings, and detailed their plans for improving the outcome item (h) assessment score within the IMSE department [8]. At the same time, the IMSE Industrial Advisory Board (IAB) began asking about the department's lean manufacturing curriculum. While the department had been teaching lean principles and tools throughout the curriculum for many years, no single course covered the topic comprehensively. The IMSE IAB challenged the

department to find a way to address this concern. At that time, several changes to the capstone design course were identified. In addition, the feasibility of an industrial kaizen experience was considered. Initial thoughts were that such an experience might fit within the capstone design course, but it was impractical to attempt this experiment on the full scale of capstone design, which averages approximately 28 students per semester. Instead, consideration was given to trying this experiment as a stand-alone exercise.

COURSE HISTORY

In 2006, Potter, Peters, and Min ran a pilot independent study course that focused on the feasibility and logistics of students participating in a kaizen event onsite at an industrial partner's facility. Four students participated in the event, including two sophomores and two seniors. The pilot study was held at a domestic site, and was very successful from all stakeholder perspectives, including students, industrial partner, and faculty [11]. Results of the study were presented to the IMSE IAB in April 2006 and were well received. As a result of the successful pilot, plans were made to create and execute a comprehensive 3-credit experimental course based on lean manufacturing. Funding was received from ISU's Study Abroad program, and an international industrial partner with multiple plant locations was found. Additionally, a domestic industrial partner was also secured for students who could not afford the international trip.

COURSE DESCRIPTION

In the Spring of 2007, two experimental 3-credit courses were offered simultaneously: IE421X (International Lean Manufacturing Systems) and IE422X (Lean Manufacturing Systems). Students enrolled in both courses attended the same lectures and had the same course requirements.

Two 50-minute class periods were held each week, and one week-long, intensive "kaizen" laboratory was held during spring break week. Lecture and discussion topics included the history of the development of lean manufacturing concepts, the Toyota Production System, the significance of valuing people within a successful lean manufacturing enterprise, the impact of culture on a successful enterprise, and many of the different lean manufacturing tools, such as kaizen (continuous improvement events), value stream mapping, kanban systems, 5S (workplace organization), setup reduction, and mistake-proofing.

Leading up to spring break week, students spent time preparing for their kaizen event weeks at their respective industrial partners. These preparations included multiple individual and group assignments based on realistic constraint identification and current event awareness (company and market specific issues related to sustainability, manufacturability, energy, economics, health and safety, politics, ethics, environment, and social concerns).

Assignments were developed to be as hands-on, visual, and experiential-based as possible. For example, the discussion on 5S included having the students actually perform a 5S analysis on the classroom. The lecture on kanban included a hands-on demonstration of inventory management of beverages in a dormitory refrigerator. Discussion on mistake-proofing included asking students for examples of any poke-yoke activities in which they had participated during internships and cooperative education experiences and sharing them with the class.

Over spring break, three teams of four students each traveled to England to work with two different Caterpillar facilities (Peterlee and Peterborough). One team of three students traveled to Waterloo, Iowa, to work with John Deere. During this week, students worked extended hours and off-shifts Monday through Friday as full-fledged members of the process improvement (kaizen) teams. These teams also included company employees and were part of the facilities' regularly planned business activities.

After spring break, students spent much of the remaining class time discussing, documenting, and presenting their kaizen events. The importance of lean concepts and tools were revisited. Likewise, the impact of culture (that was related to country and to company) was thoroughly re-analyzed. Students finished the semester by writing about and then presenting their kaizen experience and its anticipated ramifications on the industrial partner with whom they worked, including both monetary and strategic impact of the kaizen event itself. Sustainment of the activities in light of the culture of each facility was highlighted.

The course material was team-taught by Peters, Potter, and Min. The combination of the skills and interests of the three instructors brought a range of strengths to the course. While it was rare to have all three instructors in the classroom at the same time, it was useful to have all three available for different lecture topics. In addition, each of the instructors accompanied teams to their kaizen locations over spring break and served as mentors during the week.

Student grades were evaluated based on daily assignments, two exams, and a team paper and presentation. Expectations regarding both content and mechanics were clearly made for all written assignments, and students were expected to communicate as professionals throughout the course.

DATA COLLECTION AND ANALYSIS

Data was collected from multiple stakeholders throughout the course. Students were surveyed quantitatively at the beginning of the course, before and after the kaizen event over spring break, and at the end of the semester. In addition, they were asked for qualitative feedback several times throughout the semester. Industry participants were surveyed for both qualitative and quantitative feedback at the conclusion of the kaizen event week.

Students were surveyed four times regarding their opinion of how their undergraduate education at ISU has

helped them achieve the department outcome items. These results are shown in Figure 3. With respect to outcome item (h), the average score for student perception of achievement increased from 3.5 to 4.5 over the duration of the semester. These averages were based on the feedback of 15 students.

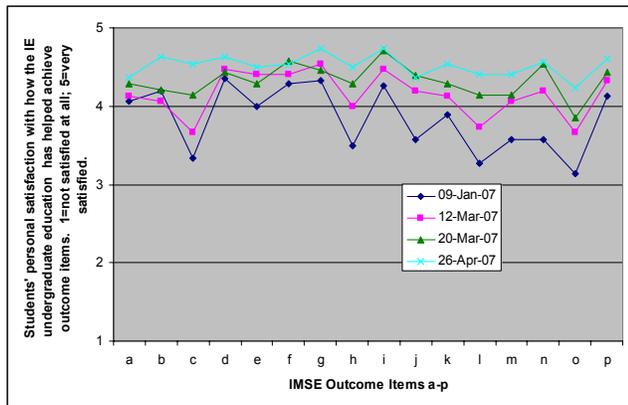


FIGURE 3

IE 421X/422X STUDENTS' PERSONAL SATISFACTION WITH HOW THEIR UNDERGRADUATE EDUCATION IN IE HAS HELPED THEM ACHIEVE DEPARTMENT OUTCOME ITEMS BEFORE AND AFTER THE KAIZEN EVENT EXPERIENCE.

In addition to assessing the value that the department provided towards achieving outcome items, students were also asked to assess the value of the kaizen event by itself in helping to achieve department outcome items. Industry participants were asked the same. The results of these surveys are shown in Figure 4. Both the students and the industry participants rated the value of the kaizen event for accomplishing outcome item (h) as very high, with the average student score at the end of the semester = 4.73 and the average industry score at the end of kaizen event = 4.42 (out of maximum score of 5). We note the comparison between the IE421X/IE422X students (4.73) and the general population score (approximately 4.0, as shown in Figure 2).

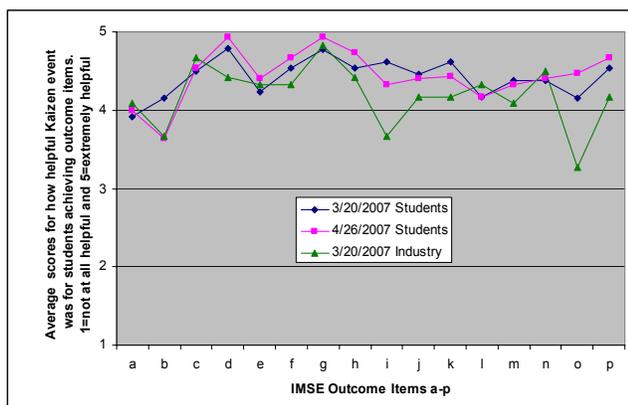


FIGURE 4

THE VALUE OF THE WEEK LONG KAIZEN EVENT (ON-SITE AT AN INDUSTRY PARTNER) WITH RESPECT TO STUDENTS' ABILITY TO ACHIEVE DEPARTMENTAL OUTCOME ITEMS.

Both of these graphs indicate that during the course, students felt a perceived increase in their ability to understand the impact of engineering solutions in a global context. Figure 4 provides significant evidence that the kaizen experience was an integral part of this improvement.

During Spring 2007 and Fall 2007, six students who took capstone design also took IE421X. The average rubric score for outcome item (h) for these six students was 14.83 vs. an average rubric score for fifty of their peers who did not take IE421X of 13.96 (min score =3, max score =18). While six students is not a large enough sample size to make definitive judgments, it appears to indicate that students who took the IE421X course with the international experience are more globally competent than those who did not.

Qualitative feedback from the students supports this data. The positive comments received during multiple survey tools, including both anonymous and accountable surveys, were numerous. Some examples of these comments include the following:

- “This is the class that I have learned the most from all IE classes. Going to work is excellent and the previous knowledge before the kaizen event was very good. I feel ready to go and do the work in the field.”
- “Location of project was amazing; keep doing it abroad.”
- “I think the cultural differences made the event more interesting for them [industry partner] as well as for our 421 team.”
- “If I had the chance to do this again I would. It was really rewarding to get a chance to work in a cross functional team and make such a huge difference in a company in just one week. It really gave me a chance to see what my potential is as an Industrial Engineer.”

Industry feedback also supports the data. Some examples of comments made by the international industry partner participants include the following:

- “Definitely “fresh set of eyes.” Worthwhile for myself to work and interact with students and experience cultural side. Share experience (2 way).”
- “Enjoyed working with people from different background and share experiences.”
- “Knowledge mixed but ranged from ‘learning’ to ‘high’; motivation all high; attitude always keen to do the work. Polite. Humouress [sic]. Participation always 100% all week.”

The industry comments were quick to point out the usefulness of the exercise to their business as well as their surprised and overwhelmingly positive reactions to working with students from another country and culture. In this way, the exercise was exceedingly beneficial – not only did students benefit in expanding their understanding of engineering solutions in a global context, but engineering and business professionals also recognized the value to themselves. It was very rewarding for the course instructors

to see the students serving as productive industrial engineers and as goodwill ambassadors.

LONG TERM IMPACT AND EXPECTATIONS

Because of the success with the first offering of courses IE421X and IE422X during the Spring 2007 semester, plans were made to offer the course again during Spring 2008. A delay in identifying and obtaining commitment from industry partners resulted in the course not being officially offered until after students had registered for the spring semester. For this reason, only eight students registered for the course. On a positive note, part of the delay in getting commitment from the international industry partner was because of complications (which were eventually overcome) with the offering of monetary support for the course. As a result of ultimately receiving the monetary support, the four students who are currently taking IE421X during Spring 2008 each received scholarships and travel support for their trip to the United Kingdom over spring break.

Currently, the Spring 2008 offering of IE421X and IE422X appears to be meeting its intended needs just as the first offering did. The combined courses address global competency, identified by both industry and academia as necessary for today's engineers, through both lecture and discussion. IE421X provides the added opportunity for students to travel to the United Kingdom to work on a week-long kaizen event at an industrial partner's site, giving them an opportunity to experience another country's culture and to learn how to generate engineered solutions alongside of people who define problems differently from themselves. The IE422X students also find that their experience in the kaizen event gives them a new perspective on defining and solving problems. The courses on lean manufacturing address the IMSE department's Industrial Advisory Board's wish for a more comprehensive approach to lean instruction; much of the instruction is centered on Taiichi Ohno's TPS foundation that valuing people is at the heart of a successful business strategy and that the workplace culture is a significant piece of achieving success in business.

Future offerings of the course will be dependent upon both department resources and industry cooperation. The classroom format and logistics require significant faculty overhead, and the decision to continue providing the lean manufacturing courses with international experience opportunities will depend on a cost-benefit analysis. If the benefits of offering such a course are perceived by all stakeholders (students, industry, faculty, and department) to outweigh the resource costs, then the future of this teaching/learning format will be continued. If the department determines that it can not afford the resources required for these comprehensive lean manufacturing courses, it is possible that "units" of instruction could be disseminated among existing courses once again, with an emphasis on tying all of the pieces together in one specific course.

While it is recognized that the sample size of students taking the lean manufacturing course is small and does not

allow for statistical significance to be measured, it does appear that the concerted changes made within the department regarding outcome item (h) since the spring semester of 2005 appear to be having some positive impact. The data in Figure 1 appear to support the continuous improvement efforts by the IMSE department with respect to outcome item (h): there appears to be an upward trend in the rubric scores for outcome item (h) as assessed for seniors in the capstone design course. Future assessments using both rubrics and surveys will be continued, and students who took the lean manufacturing courses will continue to be compared to those who did not with respect to their outcome item (h) assessments. Continuous improvement efforts will remain in place, and the impact of these efforts will be monitored on an ongoing basis. At a minimum, the data supports current efforts for improving outcome item (h) attainment. Further data will be collected to help determine whether the impact is measurably significant.

CONCLUSIONS

Assessing and improving professional skills such as outcome item (h) can be challenging, but there are ways to do so both effectively and efficiently. In this paper, we have shown that by addressing multiple stakeholder needs through a single course, significant results can be achieved, and ABET assessments indicate that actual improvement is occurring. After the completion of the Spring 2008 semester, the sample size of students involved in the experimental lean courses will be large enough to make confident decisions about the future of the courses as part of the curriculum. Future assessment and evaluation will provide further insight into the direction of this course offering. Regardless of the future of these particular courses, the evidence should be clear regarding the feasibility and effectiveness of including an international experience in an engineering course: it is possible to impact the global competency of students through coursework in the IE curriculum.

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REFERENCES

- [1] ABET, "Criteria for Accrediting Engineering Programs", <http://www.abet.org/Linked%20Documents-UPDATE/Criteria%20and%20PP/E001%2008-09%20EAC%20Criteria%2012-04-07.pdf>, accessed 16MAR08.
- [2] Shuman, L., J. Besterfield-Sacre, M., and McGourty, J., "The ABET "Professional Skills" – Can They Be Taught? Can They Be Assessed?", *Journal of Engineering Education*, Vol 94, No 1., January 2005, pp41-55.

- [3] Downey, G.L. et al., "The Globally Competent Engineer: Working Effectively with People Who Define Problems Differently," *Journal of Engineering Education*, Vol. 95, No. 2., April 2006, pp107-122.
- [4] Hochman, S. and Aimi, G., "How not to sail off the edge of a flat world," *Supply Chain Management Review*, Vol 11, No 2, 2007, pp18-19.
- [5] Cohen, M.A. and Mallik, S., "Global supply chains: research and applications," *Production and Operations Management*, Vol6, No 3, 1997, pp197-210.
- [6] Liker, Jeffrey K., *The Toyota Way*, McGraw-Hill, New York, © 2004.
- [7] Institute of International Education, "American Students Studying Abroad At Record Levels: Up 8.5%," <http://opendoors.iienetwork.org/?p=113744>, accessed 16MAR08
- [8] Potter, L. and Min, J., "ABET Outcome Assessment in an Industrial Engineering Capstone Design Course", *Proceedings of the 2005 ASEE North Midwest Conference*, Brookings, South Dakota, October, 2005.
- [9] Department of Industrial and Manufacturing Systems Engineering, "BS in IE Program Outcomes," <http://www.imse.iastate.edu/academics/accreditation/bs-in-ie-program-outcomes.html>, accessed 23MAR08.
- [10] Potter, L., Daniel, S., Popejoy-Sheriff, D., and Min, J., "ABET Outcome Assessment and Improvement through the Capstone Design Course in an Industrial Engineering Curriculum", *Proceedings of the 2006 ASEE National Conference*, Chicago, Illinois, June, 2006.
- [11] Potter, L., Min, J., and Peters, F., "Effecting Improvement in an Industrial Engineering Program by Applying Outcome Assessment Results", *Proceedings of ASEE National Conference*, Honolulu, Hawaii, June, 2007.

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